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BAYER LEVERKUSEN (GERMANY)

Department for Plant Protection

New Ways of Controlling Scab

by C. Guiliams and Dr. A. Soenen, Belgium

Introduction

Numerous tests have been carried out in the experimental plots of the "Opzoekingsstation van Gorsem" (Research Station) in Gorsem, Oostmalle, Nieuwerkerken, Jeuk and Rummen with the aim of clarifying the question as to the most suitable method of controlling scab.

Many papers have already been published on scab control, so that we hesitated considerably before deciding to publish this small contribution. Just the same we regard it as essential, particularly for the information of field workers. The staff of the Research Station at Gorsem have always considered it to be their duty to keep fruit growers up to date on the most important points concerning the control of the most dreaded diseases occurring in fruit growing.

By keeping a close observation on the emission of ascospores, we have been successful during the past few years in preventing outbreaks of scab in a most effective manner. However, it must be said that this method entails the application of a large number of sprays to ensure that the best results are obtained, although later it was found that several of the sprays which we had taken to be prophylactic, had proved to be ineffective. We shall explain in this paper on the basis of tests and figures how such ineffective sprays may be precluded.

Reference has already been made in past years to the possibilities of reducing the number of sprays by making allowance not only for the ascospore flight but also for the phaenological development of the trees. It is logical that there can be no danger of infection when there is no foliage on the trees.

In this discussion the word curative has been avoided because a really curative effect can only set in after an infection i. e. after the hyphae have penetrated into the leaf.

The method followed in compiling this paper consists of a survey of unsolved problems followed by details of tests conducted with different preparations, and finally the results obtained are discussed in general from the aspect of their relationship to the problems investigated. In addition two chapters are devoted to the flight of ascospores in 1952 and 1953.

We shall not make any further reference to the biology of scab fungus in this paper since this subject was dealt with in full in a previous paper written by us *).

*) cf. "Les Bases de l'Avertissement en Culture Fruitière". Bulletin No. 5 of the I. W. O. N. L. (1951).

The most important enemies of our fruit trees. Publication issued by the van Gorsem Research Station (1952).

I. The Problem

The warning service which, for its operation, relies on the communication of completely reliable information, has on the whole achieved good results since 1945. The warnings it issues are based on daily checks of the fungal disease outdoors and in the laboratory.

New material on the development of the fungus in relation to climatological conditions has provided us with several guiding-principles to supplement the classical warning methods. Before we go into these supplementary guiding-principles, it would be advisable firstly to obtain a clear picture of the warning methods.

A. Classical Warning Methods

A first warning is issued as soon as the "dangerous flight period of the ascospores" commences. This is followed by one or several more warnings dependent upon the rate at which the flights increase. A final warning is issued at the end of the emission of ascospores.

There are three stages in the development of the fungus:

1. Maturation of the perithecia (fructification of the fungus).
2. Emission of the ascospores.
3. Germination of these spores on the fruit and the leaf.

The conception "infection hazard" is not so much dependent upon the maturity of the perithecia or the "ascospore emission" as upon the germination of the spores on the fruit and the leaf. Moreover, germination is feasible even at very low temperatures, although it is stimulated chiefly by the moisture of the plant host (leaves and fruit). The emission of the ascospores, on the other hand, depends chiefly upon the fall of rain.

The warning, as it has been conceived to date, is based on the "maturity stage of the perithecium". As soon as the fruit grower receives the warning, he is advised to carry out an immediate treatment of those varieties which already bear leaves.

It has always been the aim of plant protection to protect the trees against scab by means of a prophylactic control.

If the treatment is followed by a period of dry weather lasting 10 to 14 days, it is only natural that the treatment will have been in vain. An infection requires a very high degree of humidity. At the end of the 10 days, the fruit grower is advised to treat the trees again to protect new leaves against possible infection. In fact the trees should be sprayed every 10 days during the critical period.

This method was found in our tests to have one disadvantage, namely that a certain number of sprays which were completely adequate as prophylactic measures, in reality did not fulfil their purpose.

B. New Information

The American research workers, Mills and Laplante, have established beyond all doubt that the leaves of the trees must remain moist at a given temperature during a certain period for an infection to occur (Table 1).

The fruit grower will have to rely in future on the warning as described above, and the climatological conditions in accordance with the data given in

Table 1. If he does this, useless sprays and sprays which have a sufficiently prophylactic effect can be reduced to a minimum.

Many will probably argue that if the warnings are only issued at the time the ascospores are ejected (in other words when it rains), several sprays can be saved. Theoretically, this would appear feasible, although in practice the fruit growers will receive the warning too late in the majority of cases for an effective control to be carried out. In fact the larger the orchard the greater are the difficulties.

An ideal warning is only feasible when the weather can be forecast several days in advance. Metereologists, however, have not yet reached the stage where they can give such forecasts knowing them to be absolutely correct so that we shall have to keep to the classical warning methods, supplemented by the experience of the past few years.

Data of Mills and Laplante

Table 1: Number of hours, as a function of the temperature, that the leaves must remain wet in order to become infected.

Temperature in ° C	Slight infection	Moderate infection	Serious infection	Period of incu- bation expressed in days
5.6	30	40	60	
6.1	25	34	51	
6.7	22	30	45	
7.2	20	27	41	
7.8	19	25	38	
8.5	17	23	35	
8.9	15	20	30	
9.4	14½	20	30	17
10.0	14	19	29	17
10.6	13	18	27	16
11.1	12	18	26	16
11.6	12	17	25	15
12.2	11½	16	24	15
12.8	11	16	24	14
13.3	11	15	22	14
13.9	10	14	22	13
14.4	10	14	21	13
15.0	10	13	21	12
15.6	9½	13	20	12
16.1	9	13	20	11
16.7	9	12	19	10
17.2	9	12	18	10
17.8	9	12	18	9
18.9	9	12	18	8
24.4	9½	12	19	
25.0	11	14	21	
25.6	13	17	26	

In Holland these methods have been recommended by several research workers as being extremely suitable provided that use is made of products based on an organic mercury compound which can penetrate into the leaf and kill the germinating fungus. Such products should retain their eradicating effect up to four days following the emission of the ascospores.

C. Definition of the Problem

We have set ourselves the task of investigating the following points:

1. Is it correct that some sprays can be eliminated?
2. Can the data of Mills based on American conditions be applied in practice to our region and to our varieties?
3. Do products based on mercury actually possess the properties specified by persons recommending them?
4. Are there other fungicides which possess the same properties?
5. How should field workers make use of warnings in future?

II.

I. The Primary Infection in 1952

As in previous years, the emission of ascospores was kept under observation also in 1952, both in the laboratory and outdoors. This work was started as soon as the first perithecia had reached maturity.

The following tables, in addition to furnishing information on the spore emissions in 1952, also give a survey of the climatic conditions at the time of the spore emission.

Table 2: Emissions of ascospores in the laboratory in 1952. Examination of batches of 24 slides with a surface area 4 cm².

Date	No. of spores	Date	No. of spores	Date	No. of spores
23. 3.	150	12. 4.	6,411	6. 5.	3,980
26. 3.	0	15. 4.	28,824	9. 5.	874
27. 3.	0	19. 4.	9,995	10. 5.	1,860
29. 3.	90	21. 4.	2,670	13. 5.	492
31. 3.	360	23. 4.	13,953	17. 5.	3,620
4. 4.	124	24. 4.	8,776	21. 5.	2,398
8. 4.	694	1. 5.	30,720	6. 6.	24
10. 4.	10,984	3. 5.	18,200		

Table 3: Emissions of ascospores outdoors in 1952. Examination of batches of 22 slides with a surface area of 4 cm².

Date	No. of spores	Date	No. of spores	Date	No. of spores
25. 3.	15	5. 5.	9,755	29. 5.	615
8. 4.	0	6. 5.	1,063	1. 6.	153
19. 4.	0	9. 5.	270	3. 6.	14
28. 4.	0	12. 5.	1,545	6. 6.	0
1. 5.	0	23. 5.	217	9. 6.	0
3. 5.	26,335	27. 5.	7,087	14. 6.	8

Table 4: Temperature and relative humidity during the critical period.

Date	Temperature in °C			Relative humidity		
	Morning	Noon	Evening	Morning	Noon	Evening
1. 5.	20.8	25.7	22.4	55 %	36 %	51 %
2. 5.	18.0	20.4	21.0	73 %	58 %	62 %
3. 5.	14.2	15.2	17.0	87 %	87 %	74 %
4. 5.	15.3	15.8	15.3	68 %	69 %	73 %
5. 5.	14.0	16.5	12.8	88 %	67 %	86 %
6. 5.	15.0	21.2	20.9	68 %	69 %	73 %
7. 5.	14.1	16.9	18.1	60 %	54 %	50 %
8. 5.	16.1	23.1	24.0	67 %	37 %	32 %
9. 5.	13.5	16.2	17.0	92 %	75 %	73 %
10. 5.	15.3	19.8	20.5	76 %	48 %	35 %
11. 5.	16.4	19.4	17.6	68 %	63 %	49 %
12. 5.	14.2	12.9	13.9	86 %	71 %	70 %
13. 5.	11.9	15.6	16.6	85 %	56 %	52 %
14. 5.	14.0	19.5	20.9	69 %	45 %	44 %
15. 5.	14.0	19.5	20.9	69 %	45 %	44 %
16. 5.	14.1	21.9	22.1	96 %	53 %	39 %
17. 5.	10.5	19.5	17.7	96 %	53 %	39 %
18. 5.	16.6	21.6	21.5	68 %	47 %	45 %
19. 5.	16.6	21.9	21.9	75 %	53 %	49 %
20. 5.	10.6	16.6	16.9	59 %	87 %	90 %
21. 5.	11.8	16.6	18.0	68 %	44 %	56 %
22. 5.	11.1	16.9	17.0	81 %	63 %	42 %
23. 5.	11.9	17.0	19.8	73 %	54 %	64 %
24. 5.	10.5	15.1	14.9	81 %	72 %	69 %
25. 5.	12.8	13.9	14.1	65 %	66 %	63 %
26. 5.	12.2	15.4	14.8	87 %	76 %	65 %
27. 5.	11.4	15.9	16.2	95 %	85 %	69 %
28. 5.	15.1	12.7	15.0	74 %	92 %	78 %
29. 5.	11.7	13.3	12.9	71 %	62 %	63 %
30. 5.	12.5	17.6	18.5	83 %	52 %	57 %
31. 5.	18.2	18.5	20.2	64 %	76 %	70 %
1. 6.	18.2	21.5	19.0	85 %	64 %	86 %
2. 6.	13.6	20.3	19.2	75 %	83 %	88 %
3. 6.	14.0	14.0	15.8	73 %	70 %	64 %

N. B. Since there was hardly any emission of ascospores owing to lack of rainfall, the figures for April have not been given. The emissions would not have caused an infection up to March 25 because the trees had still not developed leaves capable of being infected by that date.

Table 5: Rainfall and sunshine during the critical period.

Date	Distribution of Rainfall	Sunshine (in hours)			
		Quantity in mm	Morning hrs. mins.		Afternoon hrs. mins.
1. 5.	14.30—14.35; 19.50—20;	1.0	5	55	3 52
2. 5.	23.45—1.00 (3. 5.)	4.9	2	27	1 56
3. 5.	Drizzle all day; Rain 14.00—15.30	2.1	0	12	2 40
4. 5.	11.30 several drops; heavy downpour around 15.30 and 19.30	3.5	0	09	0 36
5. 5.	11.30; 12.45; 14.50; 15.55—17.35	6.5	1	27	3 13
6. 5.	22.20—0.45	1.9	6	40	3 47
7. 5.	1.15—2.00	0.9	5	20	5 20
8. 5.	3.40—9.00	2.1	6	47	5 37
11. 5.	20.00—0.45; 21.15—21.50	1.4	4	28	4 20
12. 5.	Heavy downpour around 12.00, 14.30, 16.00 and 20.45	3.5	1	32	2 15
13. 5.			3	52	3 32
14. 5.			6	58	6 05
26. 5.	Drizzle all day	1.1	0	00	0 35
27. 5.	Drizzle all morning	1.7	0	00	0 00
28. 5.	Drizzle during the day; rain from 22.30 to 1.00	6.1	0	00	0 53
29. 5.			2	43	0 06
30. 5.	2.30—2.40	0.1	3	30	3 05
31. 5.	10.30—11.30; 13.00; 19.30	5.1	1	13	1 45
1. 6.	1.00—2.00; 3.30—4.15; heavy downpours 17.45; 20.30; 21.30; 1.00	15.4	3	18	0 00
2. 6.	23.15—2.05	2.6	6	12	5 50
3. 6.			3	16	3 30

Conclusion

It is now a widely known fact that the climatological conditions which follow a flight period of ascospores, are of great importance to germination.

The germination is not so much influenced by the rainfall as by the distribution of rain. Moisture, sunshine and temperature also play their part in this.

In the field, our observations made in the examined orchards showed that there was an infection only between May 2nd and 4th.

As the flight of ascospores is only feasible in wet weather, no allowance need be made for days when there is no rainfall.

Period from May 1 to 8

- May 1: Short periods of rain. High temperature, sunshine and low relative humidity ruled out the possibility of an infection.
- May 2: Rainfall in the evening caused very large emissions of ascospores. Moisture during the night and on May 3rd led to a large infection, the most serious of that particular year.
- May 3 and 4: Likewise ejections of spores. Most of the spores were released at the beginning of this rainy period. April was very dry and warm so that the rainy period on May 2 caused the emission of the majority of spores. Therefore the spore flights of May 3 and 4 were very small with the result that they did not cause serious infection.
- May 5: Rainfall. The weather conditions on May 6 (several hours of sunshine), however, prevented the germination of the spores.
- May 6 and 7: Rainfall on these two days had no influence whatsoever because the humidity was not sufficiently persistent.

Period from May 11 to 12

The rainfall on May 11 should have caused an infection on May 12 considering the humidity. We shall see, however, that an infection did not occur. The rainfall on May 12 — should spores have been ejected on this particular date — did not cause an infection due to the weather conditions prevailing during the morning of May 13 (several hours of sunshine).

Period from May 26 to 28

Spore emissions were still to be found on May 26 and 27. There was no sunshine on these two days, and the humidity was high. The rainfall on May 26 could have caused an infection on May 27. This did not happen, however. Since late developed perithecia were involved in this particular case, the germinating power of the spores was probably too weak. However, should the rate of germination — i. e. should the spores require more time to germinate than given in Table 1 — have played a part in this, a factor which still has to be established, the weather conditions on May 28 (sunshine and low relative humidity) may have been the cause of this infection not occurring.

Period from May 30 to June 2

There were many hours of sunshine during this period. However, the humidity at night-time was not sufficiently persistent to have caused an infection.

II. The Primary Infection in 1953

The following tables, in addition to giving a survey of the ejections of spores in 1953, also give details of the weather conditions related to any possible spore emissions.

Table 6: Emissions of ascospores in the laboratory in 1953. Examinations of batches of 24 slides with a surface area of 4 cm².

Date	No. of spores	Date	No. of spores
23. 3.	5	19. 4.	5,385
27. 3.	64	22. 4.	790
31. 3.	180	13. 5.	3,955
5. 4.	2,610	10. 6.	48
13. 4.	13,130	15. 6.	0

Table 7: Emissions of ascospores outdoors in 1953. Examination of batches of 24 slides with a surface area of 4 cm².

Date	No. of spores	Date	No. of spores	Date	No. of spores
27. 3.	3	10. 4.	650	15. 5.	3,390
29. 3.	88	13. 4.	575	26. 5.	885
31. 3.	11	13. 4.	2,750	3. 6.	35
5. 4.	5,093	27. 4.	9,075	4. 6.	75
6. 4.	773	7. 5.	210	10. 6.	8
7. 4.	392	8. 5.	5,605	15. 6.	0

Table 8: Temperature and relative humidity during the critical period.

Date	Temperature in °C			Relative humidity		
	Morning	Noon	Evening	Morning	Noon	Evening
1. 5.	7.1	11.7	11.9	78 %	55 %	54 %
2. 4.	9.8	15.0	14.3	74 %	64 %	67 %
3. 4.	14.8	11.3	11.7	71 %	89 %	84 %
4. 4.	8.4	7.4	7.0	99 %	100 %	97 %
5. 4.	7.1	11.1	11.7	79 %	61 %	94 %
6. 4.	8.8	11.0	9.6	71 %	62 %	68 %
7. 4.	6.0	10.0	9.2	86 %	64 %	71 %
8. 4.	4.5	13.2	13.2	88 %	43 %	58 %
9. 4.	8.5	11.3	12.3	86 %	50 %	48 %
12. 4.	12.8	18.3	17.5	74 %	50 %	57 %
13. 4.	8.0	10.8	9.6	78 %	79 %	74 %
14. 4.	5.7	7.7	4.8	92 %	83 %	94 %
15. 4.	3.9	8.3	9.5	95 %	63 %	60 %
16. 4.	6.3	9.7	9.7	96 %	72 %	77 %
27. 4.	15.1	15.9	13.6	69 %	70 %	94 %
28. 4.	10.6	10.8	10.6	80 %	79 %	79 %
29. 4.	7.6	9.5	8.5	93 %	87 %	88 %
30. 4.	11.9	15.6	16.7	70 %	56 %	54 %
7. 5.	7.4	11.1	10.2	79 %	64 %	81 %
8. 5.	8.2	10.1	11.8	95 %	83 %	65 %
9. 5.	7.4	9.8	9.4	89 %	78 %	79 %
10. 5.	6.5	10.9	11.3	87 %	56 %	40 %
14. 5.	14.6	16.4	13.5	75 %	97 %	98 %
15. 5.	14.2	18.8	22.1	81 %	73 %	57 %
16. 5.	21.0	28.3	25.8	64 %	35 %	45 %
18. 5.	17.2	21.2	22.3	74 %	76 %	70 %
19. 5.	20.8	26.2	24.1	74 %	48 %	60 %
26. 5.	23.3	17.4	17.7	77 %	92 %	87 %
27. 5.	12.3	15.2	13.3	93 %	88 %	91 %
28. 5.	11.3	12.1	11.9	75 %	67 %	80 %
29. 5.	10.1	13.9	14.1	76 %	68 %	100 %
30. 5.	10.7	12.8	13.7	89 %	71 %	76 %
31. 5.	10.1	11.6	12.2	94 %	87 %	90 %
1. 6.	10.1	9.9	11.4	96 %	76 %	86 %
2. 6.	8.0	9.2	8.3	84 %	87 %	100 %
3. 6.	9.0	10.7	10.5	88 %	87 %	88 %
4. 6.	10.2	14.6	15.5	86 %	64 %	64 %
8. 6.	11.6	14.7	18.5	100 %	91 %	93 %
9. 6.	17.3	21.5	20.9	87 %	71 %	92 %
10. 6.	12.3	12.6	14.4	100 %	100 %	100 %

Table 9: Rainfall and sunshine during the critical period.

Date	Distribution of Rainfall	Sunshine (in hours)		
		Quantity in mm	Morning hrs. mins.	Afternoon hrs. mins.
1. 4.			3	0
2. 4.			0 40	1 09
3. 4.	12.30—15.00	5.0	0	0 12
4. 4.	9.00—16.40; 24.25	10.5	0	0
5. 4.	16.25—17.10	2.8	4 30	1
6. 4.	14.40—18.20—19.05	2.5	3 58	2 19
7. 4.			2 21	3 41
8. 4.	Rain in the evening and at night	1.5	3 25	3 27
9. 4.	Rain all day		0	0
10. 4.			1 10	5 30
12. 4.			3 30	0 54
13. 4.	2.05—5.30; heavy downpours 16.35 and 19.00	2.7	4 20	2 58
14. 4.	15.55—17.00; 23.30—24.00	2.5	2 53	0 40
15. 4.	19.30—20.00	0.5	2 10	2 26
16. 4.			0 21	0
27. 4.	13.50—19.30	4.2	0 21	0
28. 4.	Heavy downpours 12.50—13.50; 16.10—17.00; 18.15—21.00; night	6.4	2 30	2 45
29. 4.	Heavy downpours 8.30—9.05; 13.25; 16.50	2.3	2 35	2 25
30. 4.			5 55	6 20
7. 5.	5.40—7.45	5.0	2 47	0
8. 5.	12.35—12.50	1.4	1 50	3 06
9. 5.	Slight rainfall at night	0.8	1 11	0 03
10. 5.			6 55	5 23
14. 5.	14.00—18.45	3.4	3 24	0
15. 5.			0 54	3 26
18. 5.	10.45—12.00	1.4	0 15	1 06
19. 5.			3 54	4 40
26. 5.	10.50—12.15; 13.25; night	5.0	1 40	5 57
27. 5.	14.25—21.15	12.0	0	0
28. 5.			1 40	0 59
29. 5.	15.30—20.00; 24.00	4.9	2 15	0
30. 5.	7.45—8.30; 10.30—15.35	2.8	1 05	4 08
31. 5.	2.30; 7.15—12.15; heavy shower 15.45	2.7	0	0 10
1. 6.	11.00—17.00	4.9	1 50	3 12
2. 6.	2.00—5.30; 10.30—24.30	24.2	1 50	1 05
3. 6.	12.05—13.50; 17.10—18.05	5.6	1 58	4 02
4. 6.			3 15	4 48
8. 6.	10.00—10.30	0.3	0	0 15
9. 6.	night	1.1	0 43	0
10. 6.	9.00—20.00	20.7	0	0

Discussion

In 1953 we came across infections between April 8 and 9, April 27 and 28, on May 8, May 14 and between May 27 and June 3 in the plantations examined.

Period from April 3 to 9

There was a possibility of infection occurring on April 4 because on the previous day spores had been released and the general weather conditions were favourable. Admittedly the temperature was low but according to Table 1 an infection should have occurred after 24 hours. Moreover on this particular day there were already certain parts of the trees which had reached a stage capable of being infected. According to Mills all factors were in favour of an infection but it did not occur, as proved by our observation.

On April 5 the weather was sunny and dry up to 4 p.m. After the fall of rain in the evening the leaves remained wet yet even in this case there was not an infection. At this stage we are inclined to assume once again that the data of Mills are not always applicable to field conditions.

On April 6 there was sunshine in the morning, so that the leaves did not remain wet long enough.

It rained during the night of April 8 and the early hours of April 9, so that the weather conditions were in favour of an infection. However, infections did not occur in all plantations for the following reasons:

- a) The ascospore emissions were slight because flights of ascospores occurred on April 5, 6 and 7 so that on April 9 only a small number of perithecia were mature.
- b) The parts capable of being infected were very small.
- c) Owing to the long period of light rain, there was little prospect of the spores being propagated. Consequently infection occurred in the main very close to the source of infection (scab-infected leaves on the soil), whereas there was less danger of infection where the soil had been cultivated.

Period from April 12 to 15

Fine weather prevailed on April 13 with a certain amount of wind. The leaves dried quickly so that the ejections of the previous day caused no harm.

Fine weather on April 15. Consequently the ejections from the 14th did not cause an infection particularly because the temperature was very low (minimum temperature: 0°C). There was too little rainfall on April 15 to be dangerous.

Period from April 27 to 29

During this period the conditions were completely in favour of an infection. Large numbers of spores, rather high temperature, persistent humidity.

Period from May 8 to 9

The humidity on May 8 was low in plantations where strong air currents prevailed so that an infection was possible only in very dense plantations containing susceptible varieties.

The rain which fell on May 9 had not wet the leaves for a long enough period because they were all dry again after 12 a.m. The period of humidity at the prevailing temperature of 8°C was too short for an infection to be caused.

May 14

As in the previous infection, the only danger on this particular date was in plantations with little movement of air. Although the temperature here was considerably high, the humidity was not sufficiently persistent to cause a general infection.

Period from May 27 to June 3

The temperature on May 27 was most favourable. As the first fall of rain is the most important in a certain rainy period — at this stage the first spores are actually released — the greatest allowance must be made for May 27 when evaluating the results.

June 10

The climatic conditions on this particular date were completely in favour of an infection. However, as practically all the spores had been released earlier, this date can no longer be taken into consideration.

Conclusion

The following factors may be summarized as being responsible for the occurrence of an infection:

1. The number of mature perithecia.
2. The development of those parts of the plant host exposed to infection.
3. The temperature.
4. The humidity following rainfall.
5. The distribution of rainfall per day.
6. Sunshine and wind.
7. Possibly the germinating power and the rate of germination at the end of the primary infection.

The data furnished by Mills are undoubtedly of great use. Stress is actually laid upon the period of humidity as being the most important factor for the occurrence of an infection when spores are present.

Furthermore, it should be mentioned that the data may be improved on, at least with respect to our region because the climatic conditions are still capable of influencing the infection up to the second day following the flight of spores.

III. Result of the Outdoor Tests

Method of Evaluating the Results

Our counts were carried out without exception according to the methods given in our previous publications:

«Les bases de l'Avertissement en Culture Fruitière»,
„De Vornaamste vijanden van onze Fruitbomen“,
«Contribution à l'étude de la Tavelure — Méthode de comptage »
(Revue Phytiairie-Phytopharmacie No. 4, 1952).

Each leaf was given a value of 0 to 5 according to the degree of infection, and each fruit a value of 0 to 2. The figures recorded in this section, therefore, indicate a value of 2T for fruit and 5T for leaves.

In evaluating the results, it should not be overlooked that the interval between an infection and the "perceptible" damage amounts to two three weeks.

A. Tests with "Captan" (Orthocid)

This is a product of Esso Standard (Paris), which was synthesized in the laboratory of the Standard Oil Co. (U.S.A.). It is a kerosene derivative: N-trichloromethyl thiotetrahydrophthalimide.

This product, which is marketed as a whitish yellow powder, contains 50 % active ingredient, an adhesive and a wetter. It is always applied at a concentration of 0.4 %.

Test I (1952)

Location: Gorsem

Varieties: *Cox's Orange Pippin*, *Golden Delicious*, *James Grieve*, *Princesse Noble* (18 trees of each variety)

Dates of treatment: 2. 4.; 14. 4.; 5. 5.; 19. 5.; 9. 6.; 16. 6.; 1. 8.; 18. 8.; 21. 8.; 22. 9.

Result on May 29 (250 leaves per tree)

Variety	Treated plot	Check plot
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	28.4	66

Discussion

Making allowance for the number of sprays, we are forced to admit that at first sight these results do not appear to be satisfactory.

A serious infection occurred on May 3rd and 4th. Another spray was applied on May 5th. From this it follows that "Captan" (Orthocid) can partially arrest the infection two days after the emissions of the ascospores, according to these data. Why only partially and not completely?

The treatment on May 5th was carried out in the morning at 11 a.m. At 11.30 a.m. we recorded light rainfall, heavy rain about 12.45 a.m. and 2.50 p.m., and about 4.55 p.m. a thunderstorm with heavy downpours which lasted until 5.35 p.m. It is easy to understand that following such heavy rainfall some of the product may have been washed off.

This lack of effect, therefore, may not be the fault of the product. A comparison with other fungicides which were sprayed on the same day, reveals the same result.

Therefore an effect was produced by "Captan" (Orthocid) when it was sprayed two days after the emissions of ascospores.

Result on June 9

Variety	Plots	
	treated	untreated
	1000 leaves	250 leaves
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	5	77.9

Result on June 16

Variety	Plots	
	treated	untreated
	500 leaves	250 leaves
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	9.3	51

Result on July 1

Variety: <i>Golden Delicious</i> (on 1500 leaves)	
With old spots (east side)	15.1
With old spots (west side)	5.0
Without old spots (east side)	0.9
Without old spots (west side)	1.4
Comparison (361 leaves):	79

Conclusion: "Captan" (Orthocid) has a good fungicidal effect.

Variety: *Golden Delicious*

Result on July 26

Treated plot on 1000 leaves	Untreated plot on 250 leaves
1.4	120.2

Result on September 25

Treated plot on 2000 leaves	Untreated plot on 250 leaves
0.15	110.0
on 250 fruits	on 71 fruits
0	110

Conclusion

It is evident from these figures that "Captan" (Orthocid) has a very good fungicidal effect. Good results may be obtained with this preparation when sprays are applied approximately two days after the start of the ascospore ejections.

B. Tests with "Pomarsol"-Z-conc. (4289) *

This product is a zinc dimethyl carbamate (ZIRAM) containing 80 % active ingredient.

Test I (1952)

Location: Gorsem

Varieties: *Cox's Orange Pippin*, *Golden Delicious*, *James Grieve*, *Princesse Noble* (18 trees of each variety)

Dates of treatments and concentration applied: 2. 4. (0.25 %); 16. 4. (0.25 %); 5. 5. (0.25 %); 19. 5. (0.25 %); 29. 5. (0.15 %); 9. 6. (0.15 %); 16. 6. (0.15 %); 1. 8. (0.15 %); 18. 8. (0.15 %); 21. 8. (0.15 %); 22. 9. (0.15 %).

Result on May 29

Variety	Treated plot 250 leaves per tree	Untreated plot 250 leaves per tree
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	28	66

Discussion: See page 125.

* "Pomarsol-Z-conc. is now manufactured with a content of 90 % active ingredient.

Result on June 9

Variety	Plots	
	treated	untreated
	1000 leaves per variety	250 leaves per variety
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	5.4	79

Result on June 16

Variety	Plots	
	treated	untreated
	500 leaves per variety	500 leaves per variety
<i>Princesse Noble</i>	0	0
<i>James Grieve</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	9.8	51

Result on June 1

Variety	Plots	
	treated	untreated
	900 leaves	360 leaves
<i>Golden Delicious</i>	6.4	79

Result on July 27

Variety	Plots	
	treated	untreated
	1020 leaves	250 leaves
<i>Golden Delicious</i>	4.1	120.2

Result on September 25

Variety	treated plots	
	2007 leaves	200 fruits
<i>Golden Delicious</i>	0.55	0

Variety	untreated plots	
	233 leaves	100 fruits
<i>Golden Delicious</i>	100	110

Conclusion

We can conclude from these figures that "Pomarsol"-Z-conc. (4289) has a very good fungicidal effect. It still produces good results even when sprayed approximately two days after the start of the spore emissions.

Test II (1952)

Location: Gorsem

Variety: *Laxton superb*

Dates of treatments and concentration applied: 15. 4. (0.25 %); 21. 4. (0.25 %); 2. 5. (0.20 %); 12. 5. (0.20 %); 27. 5. (0.20 %); 23. 6. (0.20 %); 11. 6. (0.20 %); 11. 8. (0.20 %).

Result on May 30

Treated plot:	on 2000 leaves	0.3
Check plot:	on 800 leaves	7.6

Result on June 6

Treated plot:	on 2000 leaves	0.3
Check plot:	on 740 leaves	7.5

Result on July 17

Treated plot:	on 436 leaves	3.44
Check plot:	on 535 leaves	46.29

Test III (1953)

Location: Gorsem

Variety: *Golden Delicious*

Dates of treatments and concentration applied: 10. 4. (0.15 %); 30. 4. (0.15 %); 8. 5. (0.15 %); 28. 5. (0.15 %); 11. 6. (0.15 %).

Result on May 7

No cases of scab were detected in the check plot. Therefore, the infection of April 9 did not occur here.

Result on May 19

Effect of sprays applied on April 30 and May 8.

Treated plot on 6×500 leaves	Check plot on 3×500 leaves
0.2	9
0.2	8.8
0.6	4.8
1.2	
0.6	
0.8	

Result on June 3

Effect of sprays applied on April 30 and May 8, and atomizer application on May 28.

Treated plot on 4×500 leaves	Check plot on 3×500 leaves
1.2	12.8
1.2	16.4
1.8	11.4
0.6	

Discussion of results obtained on May 19 and June 3

There was no infection on April 8. Only the treatment on April 30, therefore, had acted against the infection of April 27.

Consequently the product is able to prevent an infection when it is sprayed three days after the start of the emissions of ascospores.

Result on June 29:

Effect of the sprays applied on April 30 and May 8, and the atomizer applications on May 28 and June 11.

Treated plot on 6×1000 leaves	Check plot on 3×1000 leaves
0.4	17.9
0.4	16.5
0.5	13.9
1.0	
1.2	
1.7	

Result on July 20

Effect of the sprays applied on April 30 and May 8, and the atomizer applications on May 28 and June 11.

Treated plot on 4×1000 leaves	Check plot on 3×1000 leaves
1.6	16.6
1.9	15.2
2.3	20.9
2.5	

Discussion of results obtained on June 29 and July 20

The slight increase established in the count taken on July 20 is not to be attributed to the product having a poor effect. We actually detected a slight infection on June 4. Normally the treatment carried out on May 28 should have had a good prophylactic effect. Therefore, it is quite probable that the product was partially washed off by the heavy rainfall at the end of May (see Rainfall Table, 1953) and at the beginning of June. The treatment carried out on June 11 did not succeed in counteracting the infection of June 4.

Conclusion

Provided "Pomarsol"-Z-conc. (4289) is sprayed 3 days, but not later than 7 days following the start of the ascospore flight, the preparation has a very good effect.

Test IV

Location: Oostmalle

Variety: *Laxton superb*

Dates of treatment and concentration applied: The preparation was applied throughout at a concentration of 0.2 %, on 9.4.; 16.4.; 15.5.; 28.5.; 15.6.; 22.6.; 9.7.

Result on May 20

Treated plot on 2×250 leaves	Check plot on 1770 leaves
0	3.8
0	

Result on June 23

Treated plot on 2×200 leaves	Check plot on 811 leaves
8	109
6	

Result on July 6

Treated plot on 5×250 leaves	Check plot on 7×250 leaves
4.8	305
6.8	308
9.6	247
4.4	308
3.2	338
	336
	405

Result on August 4	Treated plot on 3×250 leaves	Check plot on 6×100 leaves
	2.0	196.2
	7.2	157.7
	3.2	186.6
		167.5
		206.1
		118.8

Result on August 29	Treated plot on 3×250 leaves	Check plot on 3×250 leaves
	8.4	132.8
	19.6	87.6
	10	81.7

Discussion of results obtained on August 4 and August 29

In this case there is less possibility for comparison. This is probably due to the fact that those leaves which were seriously infected had fallen. In the counts taken from August 4 onwards, the scab infection is found to be slightly worse. However, this condition may not be attributed to a poor effect of the product. In fact following the treatment of May 28, the effect of the product was prematurely brought to an end due to the rainfall at the end of May and at the beginning of June. An infection occurred on June 4. No more sprays were applied until June 15. The slight infection on June 4 must, therefore, be attributed to an inadequate effect of the spray applied on May 28 resulting from the heavy rainfall.

Rainfall at this location expressed in mm

Date	Morning	Noon	Night
29. 5.	0	2.2	1.0
30. 5.	2.8	2.2	1.8
31. 5.	1.2	1.0	2.0
1. 6.	5.0	2.0	6.0
2. 6.	10.2	18.2	6.1
3. 6.	8.5	9.0	1.5

Count taken on fruit on October 7

Treated plot on	Check plot on
200 fruits	200 fruits
Total of 6 scab spots	Total of 200 fruits showing spots

Conclusion

In this test, "Pomarsol"-Z-conc. (4289) produced a good result.

C. Tests with "Tuzet" (4311 forte)

This is a combined product which contains zinc carbamate, TMTD and a new type of fungicidal preparation which has a strong power of penetration.

Test I (1951)

Location: Gorsem

Date of treatment: May 9

N. B. This test was actually planned merely for the purpose of furnishing certain information.

Result on May 24

Variety: *Melba*

Treated plot
on 500 leaves
184.4

Check plot
on 500 leaves
213.5

Result on June 6

Variety: *Melba*

Treated plot
on 500 leaves
85.4

Check plot
on 500 leaves
315.5

Result on July 6

Variety: *Melba* (1) *Red Delicious* (2)

Treated plot
on 250 leaves
per variety

Check plot
on 250 leaves
per variety

(1) 147.3

417

(2) 96.4

408.5

Result on July 6 (on fruits)

Variety: *Melba* (1) *Red Delicious* (2)

Treated plot
on 100 fruits
per variety

Check plot
on 100 fruits
per variety

(1) 103.3

(*)

(2) 76.6

174

Conclusion

We found the difference established between the treated plot and the check plot after a single treatment had been carried out following the most serious infection (May 1st), to be most interesting. Nevertheless it was impossible to draw conclusions from this test at such an early stage.

Test II (1952)

Location: Oostmalle

Variety: *Laxton superb*

Dates of treatment and concentrations applied: 15. 4. (0.25 %); 20. 4. (0.25 %); 2. 5. (0.15 %); 12. 5. (0.15 %); 27. 5. (0.15 %); 11. 6. (0.15 %); 23. 6. (0.15 %); 11. 7. (0.15 %).

Result on May 30

On 2000 leaves
Treated plot
0

Check plot
7.6

Result on June 6

On 2000 leaves
Treated plot
0

7.6

Result on July 7

On 2000 leaves
Treated plot
0

46.3

Result on September 12

On 1625 leaves
Treated plot
1.0

200.6

On 200 fruits
Treated plot
0

90

(*) The *Melba* variety growing in the check plot bore no fruit.

Test III (1952)

Location: Gorsem

Varieties: *Cox's Orange Pippin*, *James Grieve*, *Princesse Noble*,
Golden Delicious

Dates of treatments and concentrations applied: 2. 4. (0.3 %); 16. 4. (0.3 %);
5. 5. (0.3 %); 19. 5. (0.15 %); 29. 5. (0.15 %); 9. 6. (0.15 %); 16. 6. (0.15 %);
1. 8. (0.15 %); 18. 8. (0.15 %); 21. 8. (0.15 %); 22. 9. (0.15 %).

Result on May 29	Treated plot 2000 leaves per variety	Check plot 2000 leaves per variety
<i>Princesse Noble</i>	0	0
<i>Cox's Orange Pippin</i>	0	0
<i>Golden Delicious</i>	23.2	66
<i>James Grieve</i>	0	0

(For discussion of this count see Section I, Pages 114—116.)

Result on June 5

<i>Princesse Noble</i> (2000 leaves)	0	0
<i>James Grieve</i> (2000)	0	0
<i>Cox's Orange</i> (2000)	0	0
<i>Golden Delicious</i> (1000)	4.4	77.9

Result on June 16

<i>James Grieve</i> (2000)	0	0
<i>Cox's Orange</i> (2000)	0	0
<i>Golden Delicious</i> (500)	9.0 (250)	51.0

N. B. The decrease in the check plot must be attributed to the fall of the badly infected leaves.

Result on July 1

<i>Golden Delicious</i> (1500)		
With old spots	1.7	
Without old spots	0.1	79

Result on July 26

	1000 leaves	250 leaves
<i>Golden Delicious</i>	0.8	12.2

Result on September 25

<i>Golden Delicious</i>	0	110
on 500 fruits	0	110

Conclusion

In this test, "Tuzet" (4311 forte) produced an extremely favourable result. The preparation is able to arrest an existing infection and appears to have an exterminating effect on the spots because when we examined the fruit on September 25, we could not find a single scab spot.

In addition it had a very favourable influence on the foliage and the colour of the fruit (particularly on *Cox's Orange Pippin* variety).

Test IV (1953)

Location: Gorsem

Varieties: *Red Delicious*, *Melba*, *Laxton superb*

N. B. This was a large-scale test carried out to compare the effect of "Tuzet" (4311 forte) with that of barium polysulphide. Consequently there are no checks.

Dates of treatments and concentrations:

	Concentration of "Tuzet" (4311 forte)	Concentration of BaSx
1. 4.	0.15 %	1 %
28. 4.	0.15 %	0.75 %
8. 5.	0.15 %	0.75 %
15. 5.	0.15 %	0.65 %
28. 5.	0.15 %	0.45 %
11. 6.	0.15 %	0.5 %
24. 6.	0.15 %	0.5 %

Result on May 7	Treated plot on 500 leaves per variety	Treated check plot on 500 leaves per variety with BaSx
<i>Melba</i>	31.4	0
<i>Red Delicious</i>	20.8	0
<i>Laxton superb</i>	4.8	0

Discussion

BaSx produced a very favourable result which actually reflects the effect on the infection of April 9. In this test, "Tuzet" (4311 forte) appears to have given an unsatisfactory result. The cause is apparently due to the low temperature prevailing on the day the treatment was carried out. On April 9 we actually had a minimum temperature of 4.3° C and a maximum temperature of 11.9° C, in other words very low. It is possible that the product became inactivated under these conditions. In fact this was the only failure we experienced during the three years in which we tested this product.

Result on May 19 (following the infections of April 9, April 27 and 28)

	Treated plot on 500 leaves	BaSx plot on 500 leaves
<i>Melba</i>	4.0	0.4
	2.8	0.2
<i>Red Delicious</i>	10.0	0.2
	7.4	0.4
<i>Laxton superb</i>	2.0	0
	2.0	

Discussion

In this case, "Tuzet" (4311 forte) produced a good result against the infection of April 27 and 28. The scab infection did not increase but on the contrary it died down considerably. Therefore the product also exerted an influence on the infection already in existence, just as we had already observed in the tests we carried out in 1951.

Result on June 3. Influence of the infections which occurred on
April 9, April 27 and 28, May 8

	Treated plot 3×500 leaves	BaSx plot 3×500 leaves
<i>Melba</i>	2.8 2.0 2.6	0 0.2 0.6
<i>Red Delicious</i>	5.8 2.6 4.5	0.2 0.3 0.4
<i>Laxton superb</i>	1.0 0.2 1.8	0 0 0

Result on June 11

	Treated plot 3×500 leaves	BaSx plot 3×500 leaves
<i>Melba</i>	0.4 0.8 0.6	0.4 0.8 0.8
<i>Red Delicious</i>	3.8 4.0 4	0.4 0 0
<i>Laxton superb</i>	0.6 0 0.8	0 0 0

Result on June 29

	Treated plot 3×500 leaves	BaSx plot 3×500 leaves
<i>Melba</i>	0 0 0.4	0 0.1 0
<i>Red Delicious</i>	0 0 0.4	0 0.1 0
<i>Laxton superb</i>	0 0 0.1	0 0 0.1

Conclusion

Despite the poor effect against the infection of April 9 (probably due to the low temperature prevailing on the day the treatment was carried out), the result obtained with this product is after all to be regarded as excellent.

BaSx also produced a very favourable result in this test.

Test V (1953)

Location: Gorsem

Variety: *Golden Delicious*

Dates of treatments and concentrations applied: 10. 4. (0.15 %); 30. 4. (0.15 %); 8. 5. (0.15 %); 28. 5. atomized (1.5 %); 11. 6. (0.15 %).

Result on May 7

Not a single scab spot was observed in the check plot. The infection of April did not occur here.

Result on May 19

The leaves were plucked after the count.

Result of the treatments of April 10 and 30.

Infections of May 27 and 28.

Treated plot on 7×500 leaves	Check plot on 3×500 leaves
0.2	8
0.2	8.8
0.2	4.8
0.2	
0.4	
0	
0	

Discussion on the count made on May 19

"Tuzet" (4311 forte) in this test produced a very favourable result against the infections of April 27 and 28. This shows that the preparation can prevent infections when it is sprayed three days after the flight of the ascospores begins.

Result on June 3

Influence of sprays applied on April 10, 30 and May 8.

Treated plot on 7×500 leaves	Check plot on 3×500 leaves
0.2	12.8
0.6	16.4
0.2	11.4
0.4	

Result on June 29

Influence of treatments carried out on April 10, 30, May 8, 28, June 11.

Treated plot on 3×1000 leaves	Check plot on 3×1000 leaves
0.5	17.9
0.2	16.5
0.3	13.9

Result on July 20

Treated plot on 3×1000 leaves	Check plot on 3×1000 leaves
0.2	16.5
0.1	15.2
0	20.9

Conclusion

In this test "Tuzet" (4311 forte) gave a very favourable result. It can prevent an infection provided it is sprayed three days after the flight of the ascospores begins.

Test VI (1953)

Location: Oostmalle

Variety: *Laxton superb*

Dates of treatments: April 9, 16, 30, May 15, 28, June 15, 22, July 9.

The product was applied throughout at a concentration of 0.15 %.

Result on May 20

	Treated plot on a total of 750 leaves	Check plot on a total of 1770 leaves
Tree 1	0.4	5
2	0	2
3	0	3
4		7
5		1.6
6		4

Result on June 23

	Treated plot on a total of 600 leaves	Check plot on a total of 850 leaves
Tree 1	4	150
2	4	111
3	0	85
4		97

Result on July 6

	Treated plot on 5×250 leaves	Check plot on 7×250 leaves
	0	305
	0	308
	0	247
	0	308
	0	338
	0	336
	0	405

Discussion

The large increase in the check plots results from the infections which occurred on May 28 and the beginning of June (June 1st to 4th). In the discussion of this count with respect to "Pomarsol"-Z-conc. (4289), we pointed out that the treatment of June 15 was carried out too late to have had any effect on the infections which occurred at the beginning of June, and that the prophylactic effect of the treatment carried out on May 28 was also inadequate owing to the product being washed off by rain (see Page 129). This, however, does not appear to be the case with "Tuzet" (4311 forte). The good results we obtained from the count leave us with the conclusion that the preparation possesses a very good adhesive property.

Result on August 4

	Treated plot on 4×250 leaves	Check plot on 984 leaves (total)
Tree 1	1·6	118·8
	2·8	196·2
	0·4	157·7
	1·4	167·5
		186·6
		206·1

N. B. The decrease in the check plot is to be attributed in this case solely to the fall of leaves which were most seriously infected.

Result on August 29

	Treated plot on 3×250 leaves	Check plot on 250 leaves
	2·0	132·8
	1·2	
	0·4	

Result on October 7

	Treated plot on 250 fruits	Check plot on 234 fruits
	Not a single scab spot	200 fruits with scab spots

Test VII (1953)

Location: Nieuwerkerken

Preparations: This test was carried out on a large scale to compare "Tuzet" (4311 forte) with the mercury-TMTD spray combination (the TMTD preparation contained 80 % active ingredient, the mercury preparation was a mixture of phenyl mercury acetate + methoxyethyl mercury silicate).

Dates of treatment and concentration applied:

	Mercury and TMTD	"Tuzet" (4311 forte)
14. 4.	0·15 %	0·15 %
29. 4.	0·15 %	0·15 %
16. 5.	0·2 %	0·15 %
4. 6.	0·2 %	0·15 %
19. 6.	0·125 %	0·125 %
29. 6.	0·125 %	0·125 %

Infection dates for this plantation:

9. 4.	14. 5.
27.—28. 4.	27.—30.—31. 5.
8.—9. 5.	1.—2.—3. 6.

Result on May 7

	"Tuzet" (4311 forte)	Mercury
on 500 leaves per tree		
Golden Delicious	1·2	3·5
James Grieve (4×500 leaves)	0	0
Other varieties (4×500 leaves)	0	0

Result on May 19

on 500 leaves per tree	"Tuzet" (4311 forte)	Mercury
<i>Golden Delicious</i>	1.79	4.75
	4.0	0.9
	2.0	
<i>James Grieve</i>	0	2.0
	0.5	0.7
	2.5	2.1
<i>Winterbanana</i>	0.4	1.9
	0.6	1.5
Other varieties	0	0

Result on May 28

on 6×500 leaves per variety	"Tuzet" (4311 forte)	Mercury
<i>Golden Delicious</i>	0	0
	0	0
	0	1.0
	0.33	0.66
	1.0	3.0
	0.55	2.3
<i>James Grieve</i>	0	0
	0	0
	0	1.0
	0	0
	0	1.0
	6.6	0
<i>Winterbanana</i> (1×500)	0.5	0.6
Other varieties (2×2000)	0	0
	0	0

Result on May 29 (on fruits)

	"Tuzet" (4311 forte)	Mercury
<i>Golden Delicious</i> (500 fruits)	0	0
<i>James Grieve</i> (2×2000 fruits)	0.4	0
	0	0.2
Other varieties (1×2000 fruits)	0	0

Result on June 23

on 500 leaves per tree	"Tuzet" (4311 forte)	TMTD
<i>Winterbanana</i> Tree 1	1.0	2.8
2	0	2.2
3	0	4.6
4	0.8	0.6
5	0	

	"Tuzet" (4311 forte)	TMTD
<i>Court Pendu</i>	0.2	
<i>Golden Delicious</i> Tree 1	0	3.6
2	0	2.6
3	0.4	
4	0	
5	0.4	
6	0.8	
7	1.0	
8	0.6	
9	0.4	
<i>James Grieve</i>	0	1.2
		0.4
Result on June 23 (fruits)		
100 fruits per tree	"Tuzet" (4311 forte)	TMTD
<i>Winterbanana</i>	0	0
		3
		4
<i>Court Pendu</i>	0	
<i>Golden Delicious</i>	0	0
<i>James Grieve</i>	0	0.5
Result on July 22		
on 500 leaves per tree	"Tuzet" (4311 forte)	TMTD
<i>Golden Delicious</i>	0.6	2.0
	0	
	0.6	
	0	
	1.4	
	0	
	0	
	0	
	1.0	
<i>Winterbanana</i>	0.2	4.6
	0	1.0
	0	1.4
	1.0	0.6
		1.0
<i>Court Pendu</i>	0	7.8
	0	4.4
	0	8.0
	0	
	0	
<i>James Grieve</i>	0.5	2.5
	0	3.6
	0.3	5.0

Discussion

The slight infection recorded in the TMTD plot is a result of the infection which occurred on May 27—28. No treatments were carried out before this infection. The prophylactic effect of the treatment carried out on May 15 was

no longer powerful enough to prevent the infection of May 28 (the product was to a large extent washed off by the rain which fell on May 27). The fact that this slight infection was not observed in the "Tuzet" (4311 forte) plot must in all probability be attributed to the unusual adhesiveness of the preparation.

Result on July 22 (on fruits)

	"Tuzet" (4311 forte)	TMTD
100 fruits per tree		
<i>Golden Delicious</i>	0	0
	0	
<i>Winterbanana</i>	0	3
<i>Court Pendu</i>	0	
<i>James Grieve</i>	0	0

Conclusion

Very good results were obtained with "Tuzet" (4311 forte) and with the mercury + TMTD combination. The reason for the better result obtained with "Tuzet" (4311 forte) in the counts taken on June 22 must apparently be attributed to the adhesiveness of the preparation.

D. Tests with Wettable Sulphur

Test I (1952)

Location: Oostmalle

Variety: *Laxton superb*

Plot A: treated with Wettable Sulphur KR (0.5 %)

Plot B: treated with Wettable Sulphur "Bayer" (4371) (0.5 %)

Dates of treatments: 15. 4; 20. 4.; 2. 5.; 12. 5.; 27. 5.; 11. 6.; 22. 6.; 11. 7.; 8. 8.

	Plot A 2000 leaves	Plot B 2000 leaves	Check plot 2000 leaves
Result on May 30	0.05	0	7.6
Result on June 6	0.05	0	7.6
Result on July 17	0	0	46.29
Result on September 12	0.5	0	200.6
	on 250 fruits	on 250 fruits	on 250 fruits
	0	0	90

Test II (1952)

Location: Gorsem

Varieties: *Cox's Orange Pippin*, *Golden Delicious*, *James Grieve*, *Princesse Noble*

Concentration: In this test micro wettable sulphur was applied at strengths of 0.75 % pre-blossom and 0.5 % post-blossom.

Dates of treatments: 19. 4.; 2. 5.; 7. 5.; 13. 5.

	Treated plot	Check plot
	131 leaves per variety	250 leaves per variety
Result on May 29	0.7	63
	1000 leaves per variety	335 leaves per variety
Result on June 16	0.2	73

Test III (1953)

Location: Gorsem

Variety: *Golden Delicious*

Concentration: In this test 0.75 to 0.5 % micro wettable sulphur was applied.

Dates of treatments: 10. 4.; 30. 4.; 8. 5.; 15. 5.; 28. 5.; 11. 6.

Result on May 7

Not a single scab spot was observed in the check plot. Therefore, the infection of April 9 did not occur here.

Result on May 19

The leaves were removed after the count.

Result of the treatments on April 10 and 30.

Infections on April 27 and 28.

Treated plot on 3×500 leaves	Check plot on 3×500 leaves
0.8	9
0.8	8.8
1.0	4.8

Discussion

Micro wettable sulphur produced a very good effect against the infections of April 27 and 28. Therefore, the preparation can prevent an infection when sprayed three days after the ascospore flights begin.

Result on June 3

Influence of the sprays applied on April 10 and the atomizer applications of April 30 and May 8.

on 2×500 leaves	on 2×500 leaves
2.0	17
2.4	11

Discussion

Despite our application on the 30th, a slight infection occurred in this plot on May 28. Nevertheless it should not be concluded in this particular case that the wettable sulphur showed a poor effect after three days. This plot was atomized and not sprayed on April 30. Further research must be carried out to determine whether the application of wettable sulphur by atomizing three days after the start of the ascospore flights is less effective than when the preparation is sprayed.

Result on June 29

Influence of the spray carried out on April 10, and the atomizer applications of April 30, May 28 and June 11.

Treated plot on 2000 leaves	Check plot on 2000 leaves
3.2	22.4
4.8	20.2

Result on July 20

Influence of the spray applied on April 10, and the atomizer applications of April 30, May 8, 28 and June 11.

Treated plot on 2000 leaves	Check plot on 2000 leaves
6.9	21.1
3	25.9

Conclusion

From this test it may, therefore, be concluded

1. that the wettable sulphur has a good fungicidal effect when sprayed three days after the spore flights start;
2. that an atomizer application carried out three days after the infection occurs does not produce such good results as a spray. This point, however, must be given further investigation.

Test IV (1953)

Location: Oostmalle

Variety: *Laxton superb*

Dates of treatments: 9.4.; 16.4.; 15.5.; 28.5.; 15.6.; 22.6.; 9.7.

Concentration and preparation: Micro wettable sulphur, 0.75 % pre-blossom and 0.5 % post-blossom.

Result on May 20

Treated plot on 2 × 250 leaves	Check plot on 6 × 250 leaves
0	5
0	2
	3
	7
	4
	1.6

Result on June 23

Treated plot on 2 × 200 leaves	Check plot on 4 × 200 leaves
0	150
0	111
	87
	97

Result on July 6

Treated plot on 6 × 250 leaves	Check plot on 7 × 250 leaves
2.4	305
0.8	308
3.2	247
2.4	308
0.8	338
0	336
	405

Result on August 4

Treated plot on 3×250 leaves
12.4
13.6
18.4

Check plot on 6×150 leaves
196.2
157.7
167.5
186.6
206.1
118.1

Discussion

The same applies to this test that has already been said about "Pomar-sol"-Z-conc. (4289) on Page 129, namely that the prophylactic effect produced by the treatment of May 28 completely disappeared at the beginning of June due to the heavy rainfall at the end of May 4. A serious infection occurred on June 4, and anticipating the prophylactic effect no more treatments were carried out before June 15, namely at a time when the infection had already occurred.

The poor results of this count, therefore, may on no account be attributed to a weak effect of the preparation. The decrease in the check plot is due to the fall of those leaves most seriously infected.

Result on August 29

Treated plot on 3×250 leaves
21.2
24
14.4

Check plot on 3×250 leaves
132.8
87.6
81.6

Result on October 7 (on fruits)

Treated plot
220 fruits
2 spots

Check plot
200 fruits
Spots

Conclusion

Despite the poor results starting from the count on August 4, it may be said that micro wettable sulphur exerted a good effect.

Test V (1953)

Location: Jeuk

The cultures were treated throughout by means of an atomizer. Each side was only atomized once in each row because all the treatments were carried out either in calm weather or in the evening.

The test plots were halved, giving two plots each measuring 2.5 hectares (no check plot).

Varieties: *Cox's Orange Pippin*, *James Grieve*, *Golden Delicious*, *Jonathan*.

All these varieties were on Type IX.

Amount of wash applied per hectare: 200 litres.

Plot A was treated with micro wettable sulphur on 3.4. (7 %); 14.4. (6 %); 28.4. (5 %); 16.5. (4 %); 27.5. (4 %); 5.6. (4 %).

Plot B was treated with the same preparation, the only exception being that the treatment of April 28 was not extended to this plot until one day later.

Infection dates for these plantations: 4.4.; 9.4.; 27.—28.4.; 15.5.; 27.5.; 3.—4.6.; 10.6.

N. B. The treatments were carried out immediately after the infections had occurred.

Result on May 7	Plot A on 5×1000 leaves	Plot B on 5×1000 leaves
	0	0
	0	0
	0	0
	0	0
	0	0
Result on May 19	1000 leaves	1000 leaves
	no scab	no scab
Result on June 3	no scab	no scab
Result on June 29	no scab	no scab
on fruits	no scab	no scab
Result on July 20	no scab	no scab
on fruits	no scab	no scab

Conclusion

It is possible to control scab by atomizing. As no difference was established between plots A and B, it may be concluded that atomized wettable sulphur has a 100 % effect when it is applied two days after the start of the ascospore flights.

E. Tests with Mercury and TMTD

The pre-blossom treatments were carried out either with a mercury preparation (phenyl mercury acetate + methoxyethyl mercury silicate) or with California mixture.

A TMTD preparation containing 80 % active ingredient was used for the pre-blossom sprays.

Test I (1952)

Location: Oostmalle

Variety: *Laxon superb*

Pre-blossom spray with 2 % California mixture. The first infection in 1952 occurred on May 3. As the treatment on May 2 was carried out with TMTD, we can attribute the results obtained to this preparation without taking the California mixture into consideration.

Preparation and concentration: TMTD 0.2 %.

Dates of treatments: 15. 4.; 21. 4.; 12. 5.; 27. 5.; 11. 6.; 23. 6.; 11. 7.

	Treated plot on 2000 leaves	Check plot on 500 leaves
Result on May 30	0	7.6
Result on June 6	0	7.6
Result on July 17	0	46.29
Result on August 12	0	200.6
	on 500 fruits	on 500 fruits
	0	90

Test II (1953)

Location: Gorsem

Variety: *Golden Delicious*

The first four treatments were carried out with mercury (0.15 %).

The last two treatments were carried out with TMTD (0.15 %).

Dates of treatments: 10. 4.; 30. 4.; 8. 5.; 15. 5.; 28. 5.; 11. 6.

Result on May 7

No scab was observed in the check plot so that it can be concluded that the infection of April 9 did not occur here.

Result on May 19

All the leaves infected with scab were removed after the count.

Influence of the infection which occurred on May 27 and 28. Result of the treatments carried out on 10.4.; 30.4.; 8.5.

Treated plot on 8×500 leaves	Check plot on 5×500 leaves
0.2	5
0	11.2
0	9
0	8.8
0	4.8
0.2	
0	
0	

Result on June 3

Result of the treatments carried out on April 10, April 30, May 8, May 15.

on 4×2000 leaves	on 2×500 leaves
0	17
0.1	11
0	
0	

Discussion

The result of this count is to be attributed to the spray of April 30 carried out against the infection of April 27 and 28. Even if an infection had occurred on May 8, this could not be allowed for here because another spray was carried out on this date. By drawing a comparison with the check plot we find that mercury can completely prevent an infection when sprayed three days after the start of the ascospore flight.

Result on June 29

Influence of the treatments carried out on 30.4.; 8.5.; 28.5.; 11.6. (atomized).

Treated plot on 5×1000 leaves	Check plot on 3×1000 leaves
0.5	17.9
0.5	16.5
0.6	13.9
0.2	
0	

Result on July 29

1	16.5
0.4	15.2
0.2	20.9
0.2	
1.9	

Discussion

The infection established in the other plots (see section on "Pomarsol"-Z-conc. [4289], Page 129) was very slight in this plot. It may be concluded that the adhesiveness of "Pomarsol"-Z-conc. definitely played a part here, and therefore the treatment of May 28 exerted an effect which was sufficiently prophylactic to protect the trees despite the heavy rainfall at the end of May and at the beginning of June.

Conclusion

TMTD and mercury produced a very favourable result in this test. Mercury was most effective when sprayed three days after the start of the ascospore flight.

The TMTD preparation used has a very good adhesive property.

Test III (1953)

Location: Oostmalle

Variety: *Laxton superb*

Concentration: 0.2 %

Dates of treatments: 9. 4.; 16. 4.; 30. 4.; 15. 5.; 28. 5.; 15. 6.; 22. 6.; 9. 7.

Result on May 20

Treated plot on 2×250 leaves	Check plot on 1770 leaves
0	3.8
0	

Result on June 23

on 4×200 leaves	on 811 leaves
0	109
0	
5	
5.5	

Result on July 6

on 4×250 leaves	on 7×250 leaves
4.0	305
0.8	308
0.8	247
0	308
	338
	336
	405

Result on August 4

on 3×250 leaves	on 6×150 leaves
8.0	196.2
5.8	157.7
0.4	167.5
	186.6
	206.1
	110

Discussion

(see section on "Pomarsol"-Z-conc. [4289], Page 129.)

Result on August 29

Treated plot
on 3×250 leaves
12·8
9·2
11·2

Check plot
on 3×250 leaves
132·8
87·2
81·6

Discussion

The poorer result obtained from the count of August 4 onwards, may not be attributed to a weak effect of the preparation. This is due to the unsatisfactory prophylactic effect afforded by the treatment carried out on April 28 prior to the infection of June 4. Although the product possesses a good adhesive property it could not withstand the heavy rain (see Page 129 in respect of Oostmalle) at the beginning of May, and a slight infection occurred on June 4 against which the treatment of June 15 was carried out much too late.

Result on October 7

on 200 fruits
2 spots

on 234 fruits
200 fruits
with spots

Test IV (1953)

This test was carried out in a large orchard in Nieuwerkerken, to draw a comparison with the product "Tuzet" (4311 forte).

It has already been discussed in this section (see Page 140).

Conclusion

We may conclude from these tests that

1. Mercury has a very good fungicidal effect. When sprayed three days before the start of spore flights, it is capable of preventing an infection.
2. TMTD gives good results when sprayed two days after the start of the ascospore flights.

IV. Discussion of the set problems

The reader may probably ask himself why boring lists of results from numerous tests have been given in this paper. Firstly it should be mentioned that generally only the final results have been given and not so much the individual surveys.

Nevertheless in several cases it was found necessary to furnish more detailed information in order to give the reader a clear picture of the development of the disease in relation to the climatological conditions and the treatments already carried out.

Persons who conduct tests far too often draw their conclusions from a single count which has been taken at a certain time of the year, sometimes only in respect of a single variety and often only on the fruit. One sees at once how such counts can lead to great errors particularly when it is intended to draw a conclusion from these as to the value of a certain preparation.

In the following paragraphs, a survey of the problems examined will be given on the basis of the data obtained from the tests carried out.

1. *Is it correct that some sprays are carried out unnecessarily?*

Numerous observations fully confirm that very many sprays have been carried out in the field which undoubtedly were superfluous. The reason for this must not be attributed so much to inexpedient action on the part of

growers but rather to the principle of employing prophylactic methods. Individual considerations in respect of the number of controls in 1952 and 1953 will make this clear to you.

In 1952, a critical day was May 3 (also May 11 in many plantations). With one treatment, or two at the most, it was possible to control scab effectively. Yet in the majority of plantations sprays were applied from May 6 to 11. It should be mentioned that in 1952 the scab infection was on the whole very slight.

In 1953 there was no necessity to spray before April 27—28 in many plantations. In most cases two treatments had already been carried out before this date.

It is, therefore, an undisputed fact that a cut can be made. Each fruit grower will naturally ask: How can this assertion be applied in practice? Which method is to be employed in future? The answer to this is discussed in detail in para. 4.

2. Can the American data be applied in practice to our country and to our varieties?

It is not easy to answer this question. Many series of sprays have been carried out in the field on the basis of these data, and they have all produced good results. In fact it has often been established that an infection had not occurred although the conditions as specified by Mills all pointed to the likelihood of a serious infection.

It may be concluded from this that the above-mentioned data lie in a positive direction. It would, however, be wrong to consider only these figures, because in many cases influence may be exerted by the germinating power, rate at which the spores germinate, climatic conditions during a certain ascospore flight, the variety being treated, and possibly even the nature of the spore species. Further tests will have to be carried out to obtain information about this point.

3. Do products based on mercury actually possess the properties specified by persons recommending them?

In this particular year a few informative tests were carried out with one of these preparations before the blossom. The preparation was not applied again in tests during and after the blossom period because it may harm the flower buds and also because there are other products which apart from having the same fungicidal value, also exert a favourable influence on the foliage and the colour of the fruits.

There is no need to prove again that mercury preparations possess an excellent fungicidal value. It would, however, be wrong to say that mercury is a better fungicide than other preparations particularly when their secondary effects are taken into consideration.

4. Are there other preparations which possess the same fungicidal value as mercury?

Tests were conducted with the following preparations:

"Captan" (Orthocid)	0.4 %	Wettable Sulphur	0.75—0.5 %
"Pomarsol"-Z-conc.		TMTD	0.15 %
(4289)	0.25—0.15 %	Mercury	0.15 %
"Tuzet" (4311 forte)	0.25—0.15 %	BaSx	
		(Barium polysulphide)	1—0.5 %

When the preparations were sprayed 48 hours after the start of the ascospore flights, they all produced a good result. Moreover, we have already stated that certain preparations such as mercury, "Tuzet" (4311 forte), "Pomarsol"-Z-conc. (4289) and Wettable Sulphur are still active when sprayed three days after the start of the ascospore flights. With respect to Wettable Sulphur, however, it should be mentioned, as shown by the results of the tests, that when this preparation is atomized three days after the ejection of ascospores a 100 % result is not given.

No further tests were carried out in this direction with the other preparations so that no conclusions may be drawn from this in respect of the extreme importance of the number of days elapsing after the start of the ascospore flights. This also applies to those products which gave a result after three days.

5. How should field workers proceed with control measures in future?

Without any doubt the method of Mills cannot be employed easily in the field. It is not so simple, particularly for a large farm, to measure the right temperature. The moisture of the leaves differs from locality to locality.

We are of the opinion that it is still difficult for fruit growers to base their controls solely on these data.

Our warning service will continue, at least for the time being, to rely on the same principles, which first and foremost are based on the maturity of the perithecia. The most important sprays continue to be those which should be carried out during the main flight period of ascospores, i. e. in our region during the second half of April and the first half of May.

Whenever prophylactic sprays are carried out in large orchards, it is advisable to repeat the treatments about ten days later owing to the growth of new foliage.

Let us take, for example, an orchard measuring 12 hectares (30 acres) which normally can be sprayed in five days. In this case, the fruit grower will be obliged during the critical period to apply prophylactic sprays in a part of his orchard while the remainder should be treated with curative sprays. In fact, many growers are already employing this combined method (prophylactic-curative) unknowingly.

In certain cases, however, where the orchard is small and the fruit grower must carry out a special treatment against scab, he can wait for a rainy period to save time and economise in the amount of preparation to be applied. Provided the leaves remain wet after the rainfall, the grower can use a conventional type of fungicide, and he will make every effort for the treatment to be carried out as quickly as possible.

It is quite likely that in future all scab sprays will be carried out on an ever-increasing scale after the fall of rain. Should there be preparations, and this appears to be the case, which can be applied successfully four and possibly five days after the start of the spore flights, then growers can wait for a rainy period to set in without suffering any disadvantage.

Concerning the other point, namely determining whether an infection will occur or not, these data on which we rely will have to be examined more exactly with respect to our varieties and climatic conditions prevailing in our region. However, we may say now with all certainty that the infections do not occur very frequently, and it is for this reason that we are very optimistic regarding the question of economising in the quantities of preparation applied.

Gorsem, October 1953

The Problem of Cucumber Wilt

by Dr. Wilhelm Kosswig

The cucumber is infected by two fungi of the *Fusarium* genus, *Fusarium solani* from the *Martiella* group and *Fusarium oxysporum* f. *melonis* from the *Elegans* group. The two fungi may be clearly distinguished from each other by the form of the macroconidia. *Fusarium solani* (Fig. 1) possesses conidia with thick walls, well-defined septation and rounded-off apical cells, whereas in comparison the conidia of *Fusarium oxysporum* (Fig. 2) are narrower. Moreover they have a delicate membrane with poorly defined septation and pointed apical cells.

Both fungi cause a foot rot with the same symptoms on young plants.

The symptoms of disease vary considerably on old plants infested by these fungi.

Fusarium solani causes a dry rot to appear on the roots, root crown and collar of plants it infects. All parts of the stem higher up on the plant remain unaffected. When the vascular bundles are rapidly destroyed as the rot develops, this will cause the plant to collapse within a few days. However, if the tissues are only gradually infested such as is normally the case, then the disease will

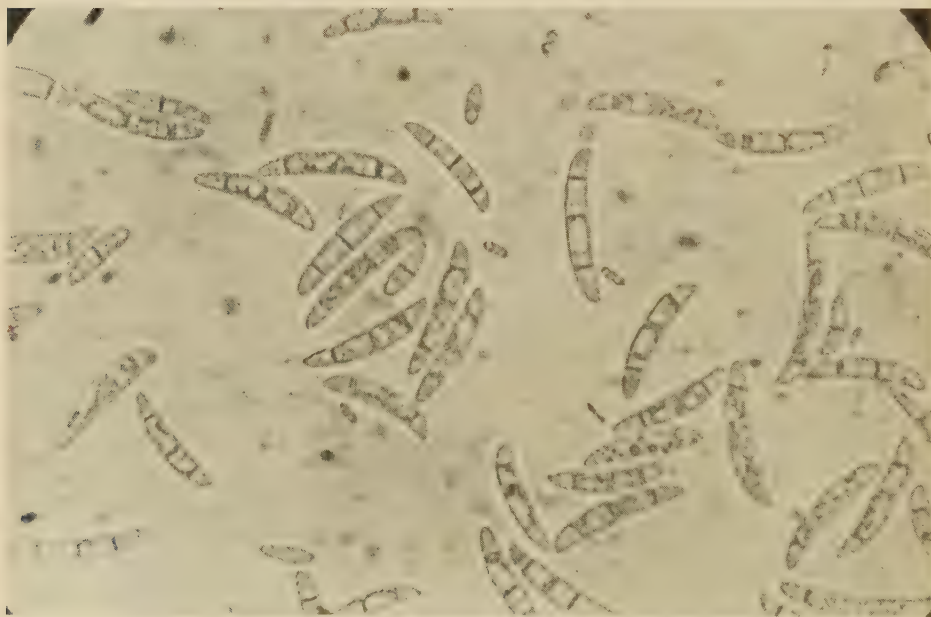


Fig. 1: Conidia of *Fusarium solani*, magnified $\times 475$



Fig. 2: Conidia of *Fusarium oxysporum f. melonis*, magnified $\times 575$

assume a chronic nature. This is characterized by yellowing of the leaves and necrosis on the leaf blades followed by a gradual enervation and drying up of the leaves. These symptoms first occur on the lower leaves of a plant and spread slowly, often over a period of several weeks, to the upper leaves.

The same symptoms may occur also following an infestation of *Fusarium oxysporum*. A closer investigation, however, will show that all stem parts, also the base of the plant, remain free of symptoms. This difference arises out of the biology of the two fungi. Whereas *Fusarium solani* as the rot pathogen primarily occurs in the outer layers of tissue on the plant parts located immediately above and below the soil surface, *Fusarium oxysporum* is to be found solely in the water conducting strands. The microscopic image shows the fine hyphae of the fungus, which form a web of threads through the vessels. When such a piece of stem is laid out on artificial nutrient medium, the fungus located inside grows out of the cut surface. Macroscopically, a browning of the vascular bundle, often spreading well upwards, is visible on stem cross-sections characterizing a symptom of infection by *Fusarium oxysporum*. This symptom also indicates the acute form of the disease, resulting in a sudden wilting of the plant accompanied by the emergence of mycelium from the stem parts — particularly at the beginning of the harvest period on naturally infected cucumbers. 1 to 2 days later, the salmon to orange-red coloured spores of the fungus, which are termed *Sporodochia*, develop on this mycelium deposit. They consist of the conidia illustrated in Fig. 2.

Purely for the sake of completing the details given, it should be mentioned that infection by *Fusarium oxysporum* may also lead to dwarfing of plants.

The similarity between the symptoms observed when the acute disease progresses on plants infected by *Fusarium solani* and *Fusarium oxysporum* resulted in both diseases being referred to as "wilt". The symptoms which accompany the chronic disease correspond to those of yellows. The two terms "wilt" and "yellows", however, do not indicate anything about the parasitic behaviour of the two fungi. If a clear distinction were to be made here, then one would have to speak of the "*Martiella-Fusariose*" instead of *Fusarium solani* and of the "*Elegans-Fusariose*" of the cucumber instead of *Fusarium oxysporum* (7).

"*Elegans-Fusariose*" occurs on a large number of plants, including many of economic significance such as tomatoes, cotton, tobacco and bananas. The pathogens are always of the "*oxysporum*" species which, however, develops various forms and also specialized forms on the respective plant host. The cucumber *Fusarium* for example, is accordingly termed *Fusarium oxysporum* f. *melonis* because in addition to occurring on the cucumber (*Cucumis sativus*), it also attacks the melon (*Cucumis melo*).

Diseases in which the parasite is restricted primarily to the vessels are termed "*tracheomycoses*". They resemble each other in two symptoms, namely in the above-mentioned restriction of the fungus to the vessels and in the browning of the vascular walls. Apart from the *Fusaria* of the *Elegans* group, there are pathogens of tracheomycoses also in other fungal genera, of which we shall mention here by way of example the *Verticillium* species with a large range of plant hosts similar to that of *Elegans Fusariose*, and the pathogen of Dutch elm disease, namely *Ceratostomella ulmi* from the *Ceratostomella* genus.

The expression "gefäßparasitäre Erkrankung" (vascular parasitic disease) often used in the German language instead of tracheomycosis is not quite to the point insofar as the vessels as dead cellular elements of the plant cannot become diseased. Just the same, consideration must be given to the possibility of the efficiency of the vascular system being affected, for example when the fungus spreads in the vessels to such a great extent that in consequence the water translocation is hindered mechanically. Frequently the parenchymatic cells adjoining the vessels are also stimulated to form thyloses due to the influence of the fungus. Such formation may lead to the vessels becoming contracted or closing up¹). With respect to the majority of the tracheomycoses, however, it is not these mechanical factors but the formation of toxins by the parasites²) which influences the permeability to water of the plasm border layers and the cellular walls in the parenchymatic tissues of the leaves and

¹) Struckmeyer et al. (14) have established with respect to oak wilt (pathogen: *Endoconidiophora fagacearum*) that the formation of thyloses and gum-like substances is alone sufficient to cause the disease.

²) The recently published paper of Davis (1) represents a contribution to the toxin theory of pathological wilt. Several *Solanaceae* are grafted on tomatoes. The infection of the grafted plants is effected with *Fusarium oxysporum* f. *lycopersici* (pathogen of tomato wilt) which is pathogenic only for the tomato. Wilt symptoms and browning of the conducting bundles occur on all scions. It must, therefore, be concluded that the production of one or more toxins by *Fusarium oxysporum* f. *lycopersici* is the cause of the observed disease phenomena particularly as the *Solanaceae* scions are not susceptible to *Fusarium*, and as tests carried out to re-isolate the fungus on the scions proved negative as expected. Reference should also be made at this stage to the publications of E. G ä u m a n n and his co-workers.

the leaf stalks on a pathological scale, that are today regarded as the standard causes for the occurrence of the above-mentioned disease symptoms — wilting, yellowing and dwarfing. Changes in the physiological behaviour of the plant host occurring in the alternation between the parasite and the host should also be given consideration when discussing the pathology of the tracheomycoses. Recent studies by American authors (2, 9, 11) have, for example, revealed a decrease in the rate of flow of the transpiration stream in infected plants without there being any toxic damage to the cells of the mesophyll of the leaves³⁾. These brief remarks on the physiology of the pathological occurrences among the tracheomycoses do show, however, that these are intricate processes and intensive research work will still have to be carried out to explain them fully.

Let us now return to *Elegans-Fusariose* of the cucumber. It is restricted to the cultivation of hothouse cucumbers because *Fusarium oxysporum* relies on high temperatures for its development in the plant, and such temperatures only prevail in cultures under glass. Moreover as it is only *Elegans-Fusariose* which occurs epidemically — in contrast to *Martiella-Fusariose* — the following details are restricted to this disease caused by *Fusarium oxysporum* f. *melonis*.

Fusarium oxysporum lives saprophytically in the soil from where it penetrates through the roots into the plant. The conidia dusted off sporodochia and the stem parts and roots left behind when a cucumber culture is removed are the sources of soil infection. Therefore, the obvious way of controlling cucumber wilt is to carry out a prophylactic control of the pathogen in the soil. There are two possibilities of doing this, namely by soil damping and soil disinfection with chemicals.

Soil damping has not proved to be a sufficiently reliable control method when applied under practical conditions. The reason for this is that the temperatures required for killing the different stages in the development of the pathogen are not reached in all parts of the quantity of soil to be moistened. Very short damping times and very moist soil are chiefly responsible for this. Unpublished observations and measurements carried out by Gerlach (3) to determine the distribution of temperature in the soil damper show that with a damping time of up to 45 minutes considerable differences in temperature may occur — according to Gerlach up to 59°C! Furthermore the tests of Gerlach revealed that *Fusarium oxysporum* — in this case a specialized form on cyclamen — is very resistant to temperatures of up to 104°C with a damping time of 45 minutes, a fact which undoubtedly may be applied to other forms of *Fusarium oxysporum*. In fact I personally came across one instance where cucumber wilt occurred in a nursery on a much greater scale following soil damping than beforehand. This phenomenon may be explained by the fact that either the temperature was too low or, assuming that the temperature was high enough, the period of effectiveness was too short to kill the wilt pathogen. On the other hand, however, the temperature-sensitive microorganisms were eliminated so that they were no longer to be considered as competitors or antagonists of *Fusarium*. As soil damping in nurseries is, in

³⁾ In a subsequent publication, Waggoner and Dimond (15) arrive at the conclusion, based on model tests, that the reduction in the rate of flow of the transpiration stream observed with several tracheomycoses cannot be explained as being solely due to mechanical factors. Additional causes should be sought among the products of metabolism of the parasites.

most cases, not carried out as thoroughly as would be necessary for the complete eradication of the wilt pathogens, either for lack of time or for technical reasons, it has only a limited value for growers as a control measure against cucumber wilt.

To carry out chemical soil disinfection, there are only Formalin and trichloronitromethane (a new preparation known under the name of chloropicrin) available. Other soil disinfectants such as 8-hydroxyquinoline sulphate (Chinosol), or preparations containing pentachloronitrobenzene and trichlorodinitrobenzene as their active ingredient have proved to be ineffective. Even Formalin



Fig. 3: Grafting of cucumber on pumpkins: Tongue grafting

is not always fully effective. Consequently only chloropicrin is left which past experience has shown to be extremely effective against *Fusaria*. It also kills cucumber wilt *Fusarium*. Unfortunately chloropicrin is a liquid which evaporates quickly, and which acts as a tear gas so that it can only be applied provided special precautionary measures are taken. This may be regarded as one of the main difficulties which have so far held up the application of chloropicrin as a soil disinfectant in German nurseries. Resultantly, chemical soil disinfection, too, cannot be considered for the time being as a measure for controlling cucumber wilt in practice because of its inadequacy.



Fig. 4: Grafting of cucumber on pumpkin. Tongue grafting (grafted plant on its own root; point of grafting fixed with lead foil).

During the past decade, a completely different process has been developed in Holland for controlling cucumber wilt, namely the grafting of cucumber on pumpkin, a method which has been widely introduced in cultivation practices and which past experience has shown to be fully effective. The method is based on the idea of isolating the cucumber from the soil by means of a stock which is not susceptible to *Fusarium oxysporum*. *Cucurbita ficifolia* has proved to be the best stock among the pumpkin varieties tested.

Only two of the many different grafting methods have gained practical significance: side grafting (5) in which the scion of the cucumber is inserted laterally underneath the seed leaves of the pumpkin plant, and tongue grafting (6) in which the pumpkin and the cucumber are inserted in each other (Fig. 3) so that both plants stand on their own root during the period taken by the point of grafting to grow together (Fig. 4). The contact to the cucumber root is severed about 10 to 12 days after grafting. The pumpkin shoot is cut back to 1 or 2 foliage leaves.

Groenewegen (4, P. 170) recently reported that the side grafting method is nowadays only applied in nurseries located in the region around Amsterdam whereas in all other places use is made of tongue grafting, also in Germany.



Fig. 5: Grafted plant: Cucumber root has grown through the pumpkin stock into the open.

Although it has been mentioned above that *Cucurbita ficifolia* is not susceptible to *Fusarium oxysporum*, a certain limitation must be set to this statement. In infection experiments carried out in the laboratory and also in the examination of pumpkin stocks from removed cultures, *Fusarium oxysporum* was re-isolated in approximately 15 % of all cases without there being any

outward symptoms whatsoever visible on either the pumpkin stock or the grafted-on cucumbers. Investigations into the localisation of the fungus in the pumpkin stocks have not yet been completed. It is highly probably that the point of grafting represents a border zone through which the *Fusarium* is not able to grow, particularly as there has so far not been a single case where the fungus has been traced in the examination of the cucumber scion. It is, however, intended to repeat the investigations because Groenewegen (4, P. 174) reports on an observation made in Groningen, Holland, whereby *Fusarium* infestation was established "in several cases" also above the points of grafting.

It is possible for a grafted cucumber to become infected when adventitious roots of the cucumber penetrate into the soil. Therefore, when cultivating grafted cucumbers it is important to avoid this danger of infection to the plant. In my own experiments where grafted and non-grafted cucumbers were grown alongside each other under practical conditions, it was found that the tendency of grafted plants to form adventitious roots is slighter than that of non-grafted plants. In these tests which were carried out in the Summer of 1953 and 1954, the adventitious roots were cut off both on the grafted and on the non-grafted plants approximately 14 days after planting which was done in the middle of July — naturally before the plants grew into the soil. Whereas adventitious roots soon began to form again on the non-grafted plants, hardly any new adventitious roots appeared on the grafted plants and even these stopped growing before they reached the soil surface. Since the formation of adventitious roots is stimulated by high relative humidity close to the soil, this can be effectively countered by watering the cucumber cultures only at long intervals and by keeping the base of the plants dry (by making irrigation channels). According to reports from growers, the growth intensity of adventitious roots is so slight when the plants are watered properly that it is not necessary to cut them back.

If it is assumed that the infection of grafted plants observed in Groningen was not caused by the *Fusarium* penetrating through the adventitious roots, then the infection may also be explained by the fact that a cucumber root can penetrate from the point of grafting into the hollow pumpkin root through which it grows into the open (Fig. 5). This, however, is a very rare occurrence. In an examination of 138 plants from three cultures — the two tests already mentioned carried out at the Institute in the summer months of 1953 and 1954, and a growth test conducted at the Research Station Limburgerhof in 1954 — this phenomenon was only found four times. This result would correspond well with the observation made in Groningen where *Fusarium* infection was only found in a few cases on grafted cucumbers.

More frequent cases were observed of the ingrowth of one cucumber root — the counts gave a result of 31 % — which in all cases died off (Fig. 6). On the other hand, many ingrowing cucumber roots were found on growing plants. An examination of two lots of 35 and 44 plants carried out 42 days and 73 days respectively after grafting showed that there was one ingrown cucumber root on 52 % and 57 % respectively of all the plants, giving an average of 53 %. The displacement of 53 % on the growing plants to 31 % on the plants which have stopped yielding may probably mean that the ingrown cucumber roots die relatively quickly so that the formation of the ingrown cucumber root can no longer be recognized in many cases.

In contrast to these observations, we also have the results obtained by Welte (16).

In 1951 he made comparisons in Württemberg nurseries between tongue graftings and cleft graftings (5) in which the cucumber scion is inserted above the first or second node of the pumpkin stock. He found that on tongue graftings there was a total of 30 to 50 % of grown-through roots in practically



Fig. 6: Grafted plant: Cucumber root which has grown into the pumpkin stock and died.

every instance and a loss due to wilt of "up to 30 %", whereas cleft graftings always remained healthy. There appears to be no explanation for these results which contradict my own observations. It can only be said that as far as I could establish, such failures with tongue graftings have not been reported either in the cultivation of forced cucumbers in Holland or in local nurseries. I was informed from all quarters that losses due to wilt were not recorded even in infected cucumber plots. In contrast to cleft grafting as recommended by Welte (16) on the basis of his results, and also in contrast

to side grafting as practised in the Amsterdam nurseries, tongue grafting has the great advantage that it does not require any special measures being taken for the breeding of grafted plants such as is the case with the other methods in which the plants have to be covered with an extra layer of glass in the greenhouses in order to produce the high relative humidity necessary for starting the growing-together process because from the very outset the cucumber scion is connected with the upward moving sap stream only by means of the stock.

This survey shows that tongue grafting is a practical and useful process for controlling cucumber wilt.

As *Cucurbita ficifolia* has a considerably stronger vegetative growth than the cucumber, it was believed that from the first test results obtained, the conclusion could be drawn that the harvest of grafted plants would be delayed. In the meantime this has proved to be just the opposite. Harvesting starts earlier and the yield is larger than that obtained from non-grafted cucumbers. Groenewegen (4, P. 172) believes that the cause of the initial failures is due to the fact that the technique of grafting and the subsequent treatment of the plants was not properly mastered at the time. Today it is recommended to leave 1 or 2 foliage leaves on the stock. If there are more than two leaves the grafting point does not grow together so quickly; if all the parts of the pumpkin above the point of grafting (including the cotyledons) are removed, this has an adverse effect on the development of the root system (4, P. 171).

Groenewegen (4, P. 172) gives an example of early harvesting with grafted plants by quoting counts taken in 1950 in three nurseries located in the outskirts of Rotterdam. With planting dates between March 11 and 16, average yield increases of 3.3, 5.6 and 7.3 fruits per plant were obtained for grafted cucumbers up to May 31st.

An experiment carried out by Irmgard Siemer (12) in 1951 at the request of the Institute at the Neuburger Hof near Opladen also showed that the harvest was ready for early picking. With plants set on May 8 and the start of harvesting on June 30, an average of 5 fruits per grafted plant and 1.8 per check plant were yielded by July 11. The corresponding figures on July 25 were 12.6 and 8.5 fruits per plant. In 1951, Welte (16) also established in several nurseries, with an average of 9.2 against 7.8 fruits, a higher yield on tongue grafted plants during the first period of the harvest season from May 29 to June. These plants had been set around the middle of April. The cleft grafting produced 10.3 fruits per plant. It is worth mentioning with respect to the test results of Siemer and Welte, that after the grafting point had grown together (10 to 12 days after grafting), all the pumpkin leaves, including the cotyledons, were removed.

In my own test to which I have already referred and which was conducted in 1953 in the nursery of the Institute — the plants were not set until July 13 — an earlier or greater harvest was not established on grafted plants. During the first two weeks after the harvest had begun, i. e. from August 15 to 29, an average of 2.6 fruits per plant were yielded on the grafted cucumbers and 2.8 on the control plants. The figures increased to 5.3 and 5.5 fruits per plant respectively by September 10 (4 weeks after the start of the harvest). The difference of 0.2 fruit in each case is well outside the statistical limit of reliability.

The lead in development which the non-grafted plants held at the outset was caught up with by grafted plants by the time the harvest started. On July 29 (16 days after planting) the cucumbers were graded according to the length of their main shoot which at the same time characterizes the number of leaves formed up to that time. The figures 1 to 4 were used for the purpose of the grading (1 = larger than 140 cm; 2 = 110—140 cm; 3 = 80—110 cm; 4 = smaller than 80 cm). The grafted plants were given the rating of 2.2 whereas the checks were graded at 1.4. The plants were graded again about two weeks later, on August 10 (five days before the harvest). This time they were graded with the numerical values of 1 to 3 (1 = top shoots pinched off, long lateral shoots; 2 = top shoots pinched off, short lateral shoots; 3 = top shoots not yet pinched off, length of less than 2 m). With a rating of 1.8 for the grafted cucumbers and 1.5 for the check plants, it was no longer possible to establish a statistically reliable difference.

The initially weaker development of grafted plants was also evident in the test conducted in the same manner in 1954 and in which the plants were also set in the middle of July. The grafted plants were divided into two groups. In the first group all parts of the pumpkin, including the cotyledons, above the point of grafting were removed after the latter had healed, while in the second group the pumpkin was cut back to one foliage leaf. The pumpkin shoot which, with few exceptions, developed after planting was trimmed to four leaves. On July 30 (17 days after planting), the check plants had an average length of 86 cm with 12 internodes. A length of 69 cm with 10 internodes was measured for the grafted plants with a pumpkin shoot, and 28 cm with 7 internodes for the plants without a pumpkin shoot. The differences are statistically reliable. The existing pumpkin leaves, therefore, undoubtedly had a favourable effect on the development of the root system.

By September 7 (8 weeks after planting), the difference in development between the check plants and the grafted plants of group 2 (plants with pumpkin shoot) had been adjusted. On this date the top shoots were pinched off on 64 % of the check plants and on 67 % of the plants of group 2, whereas among the grafted plants of group 1 (all parts of the pumpkin removed above the point of grafting) only 29 % had grown to a length necessary for pinching off the top shoots. These figures, too, indicate the favourable influence exerted by the pumpkin shoot on the development of grafted plants.

The unusually slow growth of the plants in this test — for plants set on July 13, the pinching off of the top shoots should normally have been started four weeks later — is qualified pathologically. The purpose of the test was to clarify the susceptibility of grafted and non-grafted plants to *Cladosporium cucumerinum*, the pathogen of gummosis. Disease symptoms appeared on the shoot tips of several plants only 14 days after planting. The infection then increased rapidly, and by the time the first fruit sets had formed it had reached the epidemic stage and inhibited the development of the plants. For this reason it has also been decided not to give the harvest results here.

In the test conducted in 1951 by Siemer (12), the development of the grafted plants was favourably influenced. These plants had been set on May 8. On May 11, the average surface area of the largest foliage leaf of each grafted plant was almost 100 sq. cm whereas the surface area of the corresponding leaves of the check plants was only about 70 sq. cm. This difference in the surface area of the foliage leaves had been adjusted by June 2

(25 days after planting). There were no statistically reliable differences in the lengths of the plants.

The more vigorous growth of the grafted plants is also illustrated by the number of lateral shoots which develop during the period of intensive growth from May 25 to June 26 (planting May 8; start of harvest June 30). On the average, each grafted plant has 26 lateral shoots in comparison with 19.5 shoots on each check plant at the end of this period. The difference was even greater on June 14 when 22.3 and 11.5 lateral shoots respectively were counted. There was no difference between the two groups with respect to the development in the length of the plants. The average number of internodes is about the same for both groups with 25.4 on grafted plants and 25.5 on non-grafted plants. Despite the stronger vegetative growth, the grafted plants are ready for harvesting earlier, as already numerically established. This is also shown by the number of female flowers which form between May 25 and June 22. The grafted cucumbers bear the first female flowers on May 30 (4 days before the check plants). The average numbers per plant on June 9 are 9.6 (grafted) and 5.8 (non-grafted), and on June 16 26.1 and 19.7 respectively. On June 22, the difference has practically disappeared with an average total number of developed female flowers per plant amounting to 36.5 and 37.2 respectively.

From the comparison of the results obtained by Siemer (12) and Welte (16) with the tests conducted at the Institute's nursery in the summer months of 1953 and 1954, it is seen that the grafted cucumbers, both in development and yield on early cultures, were superior to the non-grafted check plants.

According to Groenewegen (4, P. 172), grafted plants tolerate low temperatures far better than non-grafted cucumbers, and therefore it might be conceivable that the better growth of grafted plants would be noticeable particularly among the early cucumber cultures. In view of the fact that Groenewegen (4, P. 174) also points out the slighter compatibility of the pumpkin stock with high temperatures, which is to be assumed as highly probable, then the initial slow development of the grafted plants in comparison with the checks in my own tests conducted in 1953 and 1954 might be explained as being due to late planting in the middle of July and to the relatively high air and soil temperatures prevailing in the greenhouse at that time. In order to make a further study of this question, it is intended in 1955 to compare grafted and non-grafted plants in an early and in a late culture.

A further problem related to grafting which has already been mentioned, is the greater susceptibility of grafted plants to gummosis, often maintained by growers. Groenewegen (4, P. 174) was not able to establish any differences in laboratory tests although he believes that it is possible for grafted plants to be more susceptible under practical conditions. A final opinion based on my own tests cannot yet be given.

In the 1953 test, the yield in the first harvest period — middle of August to middle of September — was quite normal with 5.3 (grafted) and 5.5 (non-grafted) fruits per plant, although in the following harvest period the occurrence of gummosis was more serious. On October 15, three months after planting, the infection was so bad that the test had to be discontinued. The yield had dropped equally on both grafted and non-grafted cucumbers, and amounted to 3.4 and 3.2 fruits respectively per plant in the second harvest period. Actually the yield should have increased in this second harvest period.

In the 1954 test, gummosis appeared before the blossom, and very soon spread epidemically. The first fruits which should have been ready 4 to 5 weeks after planting on July 13, were not cut until September 10. The test was discontinued on October 26. The harvest which under normal conditions should have yielded between 10 and 15 fruits per plant, produced an average of 2.5 fruits on grafted plants and 3.3 on non-grafted plants. An answer still has to be found to the question whether the difference of 0.8 fruit, which is very close to the limit of statistical reliability, is due to a higher percentage of infected fruit sets which then die off on the grafted plants. At all events, the percentage of diseased cucumbers was more or less the same among the harvested fruits with 76 % on grafted plants and 77 % on non-grafted plants.

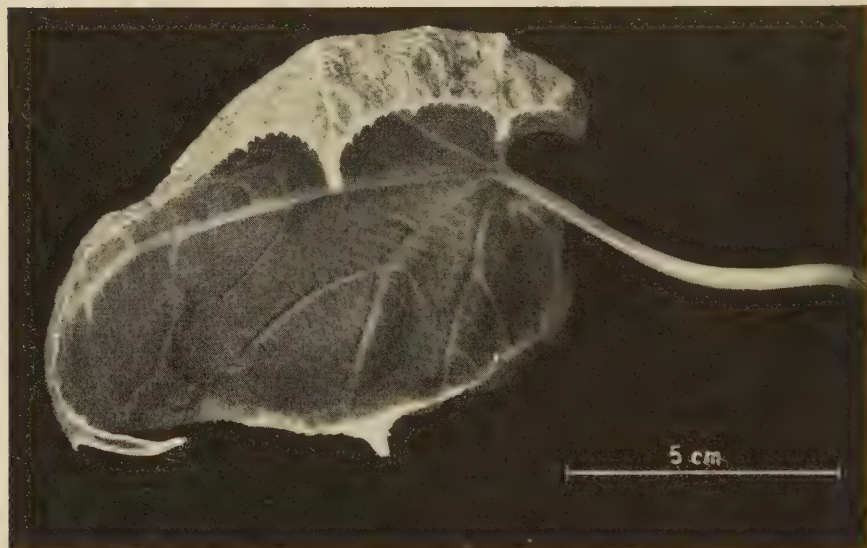


Fig. 7: Cucumber treated with 4-chloro-3,5-dimethyl-phenoxyethanol. Leaf showing cap-shaped deformation.

As far as we can judge hitherto the results of both tests carried out in 1953 and 1954 there seem to be no special differences in the susceptibility of grafted and non-grafted plants to gummosis.

As explained, the grafting of cucumbers on *Cucurbita ficifolia* is at present the most effective method of controlling cucumber wilt. On the other hand, however, all market gardeners would very much appreciate the introduction of an easier method to replace grafting. There are two possibilities, the systemic treatment of wilt and the breeding of resistant varieties.

It may be assumed that the breeding of resistant varieties will very probably prove successful because good results have also been obtained in this way against other tracheomycoses, e. g. the *Fusarium* wilt of cotton, tobacco, cabbage, tomatoes and asters. The cucumber grower, however, finds himself faced by yet another major difficulty. He requires a useful selection method

which will allow him to check a very large number of plants within a minimum of time.

Since the cucumber wilt only occurs on cultures grown under glass, and the incubation period lasts on the average between 42 and 49 days after planting, it is easy to see that the area which the grower has available under glass would only allow him to check a small number of plants. An important condition for a selection method is, therefore, a shortening of the incubation period. By cultivating the plants in nutrient solution at sufficiently high temperatures — daily mean temperature between 20 and 30°C, with peak temperatures above 25°C — it was possible to cut the incubation period down to an average of 11 to 12 days. The addition of copper to the nutrient solution resulted in a further reduction of 1 to 2 days. This observation, however, is only of theoretical interest because it permits an insight into the physiology of pathological wilt. This additional reduction of the incubation period is not necessary for a selection method particularly as the cucumbers show undesired growth inhibition even when only slight additions of copper are made.

In addition to the temperature, the degree of acidity of the nutrient solution appears to be of considerable importance as regards the length of the incubation period. At pH values of 5.1, 6.3 and 7.7, average incubation times of 11.3, 14.8 and 17.1 days respectively were determined. The incubation times increased to 9.2, 15 and 26.1 days respectively in copper-containing nutrient solutions with the same pH values. In order to obtain a more exact recording of the pH influence, those tests which in the past were carried out under the climatic conditions of small greenhouses will have to be repeated under constant temperature conditions.

It occasionally happens that plants do not become sick even when the pathogen has penetrated into them. Such cases are of particular interest for two reasons. On the one hand, proof must be obtained whether this tolerance is a hereditary property of the plant. On the other hand, a check must be made whether there is any similarity between this and the behaviour of the fungus towards *Cucurbita ficifolia* because, as has already been mentioned, *Fusarium oxysporum* is able to penetrate into the pumpkin without causing disease symptoms.

In reply to the question about the resistance of hothouse cucumber varieties on the market today, it must unfortunately be said that without exception they are extremely susceptible to wilt.

Moreover, no useful chemicals have yet been discovered for the systemic treatment of cucumber wilt. It has been established, however, that fungal diseases can be controlled systemically. Therefore, it is by no means impossible that at some time a compound will be discovered which will also be effective against cucumber wilt. The development of systemic fungicides, however, involves considerable difficulties which are mainly due to the fact that because of the fundamental similarity between the plasm of low and tall plants, it is by no means easy to find compounds which act on the parasites either direct or indirect yet at the same time do not injure the plant host. In other words, it is extremely difficult to find substances with a favourable chemotherapeutic index.

This problem has been satisfactorily solved for the control of *Fusarium* wilt on carnations, which like the cucumber wilt is a tracheomycosis. Stoddard and Diamond (13) have reported on this. The carnations are sprinkled

with 4-chloro-3-5-dimethyl phenoxyethanol, a compound related chemically to the 2-4-D preparations which are known as hormone-like weed killers. In one test carried out in a nursery, there were only 3.2 % diseased carnations in the treated plots as compared with 50.6 % diseased plants in the check rows.

It was quite natural also to test this substance for its effectiveness against the cucumber wilt. Unfortunately the result proved negative for practical



Fig. 8: Cucumber treated with 4-chloro-3-5-dimethyl-phenoxyethanol. Leaf with light veins.

purposes. 77 % of 26 treated plants suffered from wilt 58 days after the infection. In the untreated check, 9 of the 10 plants became sick in the same period. It was considered increasing the applied concentration to give a better effect, but this was of no avail because of the poor compatibility of the preparation with plants. Serious harm is caused in the region of the plants. The symptoms take the form of light veins and vein ruptures in combination with growth disturbances which lead to cap-like or dish-like deformations (Fig. 7—9).

On the other hand, the result of this test series is much more pleasing from the scientific point of view. It is obvious from the lengthened incubation period in the case of the treated plants that the preparation had a certain effect. Furthermore, it is evident from the deformations of the leaves that the pre-

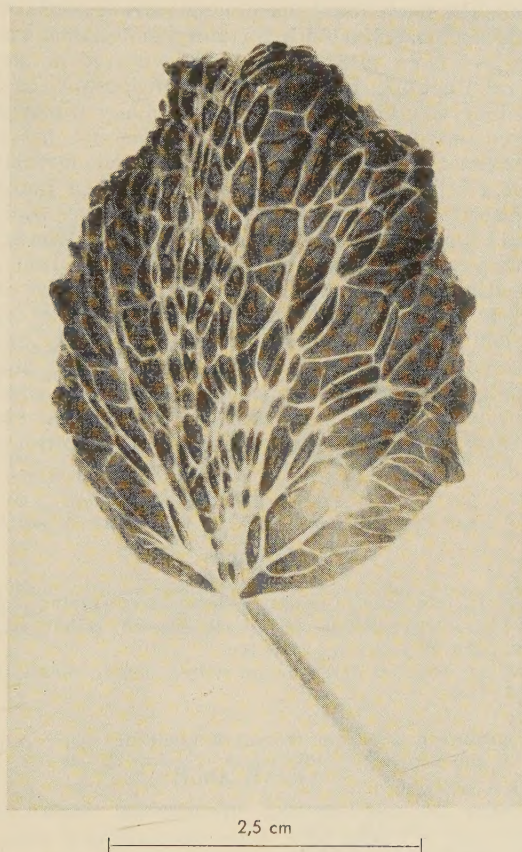


Fig. 9: Cucumber treated with 4-chloro-3,5-dimethyl-phenoxyethanol. Leaf with cap-shaped deformation and vein rupture.

paration has not lost its growth regulator character with respect to the cucumber. Finally the symptom of light veins allows conclusions to be drawn about the breakdown of the compound in the plant. According to studies made by Resühr (10), light veins are characteristic of poisonings by phenol-like substances. This also applies to the above-mentioned systemic fungicide, and

it is most conceivable that chemically there would be no difficulties as regards its decomposition to form a phenol.

Consequently, the grafting of cucumbers on *Cucurbita ficifolia* still remains the only possibility of effectively controlling wilt.

Among the numerous problems concerning cucumber wilt which have to be solved by the scientist and the grower, there is one more which should be mentioned, and it is probable that a complete answer to it will never be found. It has been established from inquiries among growers that an occurrence of cucumber wilt was not observed with certainty in German cucumber growing areas before 1946. Yet from 1948 to 1950, wilt occurred as an epidemic in all parts of the Federal Republic, only to recede considerably in 1951. At present it is merely of minor significance. As a result many nurseries have already stopped grafting cucumbers again. Because it was not possible to establish the epidemic occurrence of wilt, it cannot be predicted whether this disease will again present a serious threat to the cultivation of hothouse cucumbers. The only point of any certainty is that high temperatures such as may prevail under glass, are always a particular source of danger. Growers can only hope that the development of cucumber wilt was similar to that of the bacterial tomato wilt, likewise unexplained. Tomato wilt was first observed in 1927 in Germany, and a few years later it had become of great importance to tomato growing. The bacterial tomato wilt has practically disappeared today. Kotte (8, P. 208) wrote: "It appears at present as if the disease has temporarily lost its impetuous power of attack such as was also observed with other plant diseases. Just the same, it must still be regarded as really dangerous." Such a warning may also be given concerning the cultivation of hothouse cucumbers.

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Versuche zur Bekämpfung der Gurkenwelke durch verschiedene Pfropfverfahren. (Test controls of cucumber wilt by means of various grafting methods.) Südd. Erwerbsgärtner 5, 512—513, 1951, and 6, 5—6, 1952.

Book Review

Schimitschek, Prof. Dr. Erwin: „Die Bestimmung von Insektenschäden im Walde nach Schadensbild und Schädling“ (“The determination of insect damage in forest from the injuries caused and the pest”).

1955 / 196 pages with 290 illustrations / art paper / bound completely in linen / DM 19.80 / Publisher: Paul Parey, Hamburg and Berlin.

It is essential to make a satisfactory diagnosis in order to ensure that pest control and plant protection measures are carried out properly. To help make such a diagnosis there are numerous reference books available which for this reason are of extreme importance in plant protection, too. These books become of greater importance the more our knowledge of the causes of damage increases, as the technique employed in carrying out controls progresses, and as the possibilities increase for an aimed application of counter measures for the purpose of attaining a maximum useful effect and a minimum of secondary effects. Therefore the work written by Schimitschek is an extremely valuable addition to our aids in forestry protection, and for the above reasons its value is not so easy to assess.

A precise survey of the damage caused, restricted to the most important details, brings to light the origin of the respective damage. Any doubts which may arise are removed by a large number of selected and excellently reproduced illustrations.

The book is most simple to follow, and is used in the normal manner with the aid of reference tables subdivided on the one hand according to the occurrence of the damage in plant gardens, cultures and other stocks, and on the other hand according to the parts of the plant bitten by the pests. This simplifies and shortens the determination.

A description is given of the damage caused by insects and mites in forestry all over Central Europe, both in the lowlands and in the highlands. Apart from the coniferous and leaf trees of the forests, mention is also made of the most important insect damage on fruit trees. In this respect, however, several important pests such as *Capua reticulana*, *Bryobia praetiosa* and *Paratetranychus pilosus* not mentioned here might be included in a subsequent edition.

Field workers, students and scientists will gratefully welcome the publication of this excellent and valuable work.

Dr. Unterstenhöfer